TWOPAS PROGRAMMER'S GUIDE

A Programmer's Guide to TWOPAS — A Microscopic Computer Simulation Model of Traffic on Two-Lane, Two-Way Highways

July 1986

U.S. Department
of Transportation
**Federal Highway
Administration**

Research, Development,
and Technology
Turner-Fairbank Highway
Research Center
6300 Georgetown Pike
McLean, Virginia 22101

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle	5. Report Date
TWOPAS PROGRAMMER'S GUIDE	15 July 1986
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
A. D. St. John and D. W. Harwood	7533-S(6)
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Midwest Research Institute 425 Volker Boulevard Kansas City, Missouri 64110	11. Contract or Grant No. DTFH61-82-C-00070
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address Federal Highway Administration Turner-Fairbank Highway Research Center 6300 Georgetown Pike McLean, Virginia 22101	Computer Program Documentation March 1984 - May 1986
	14. Sponsoring Agency Code

15. Supplementary Notes

FHWA Contract Manager: D. L. Warren (HSR-30)

16. Abstract

This Guide presents information required by programmers to understand or modify the program logic of TWOPAS, a microscopic computer simulation model of traffic on two-lane, two-way highways. The TWOPAS model simulates traffic operations on two-lane highways by reviewing the position, speed, and acceleration of each individual vehicle on a simulated roadway and advancing those vehicles along the roadway in a realistic manner. TWOPAS has the capability to simulate both conventional two-lane highways and two-lane highways with added passing lanes. This Guide documents the overall model structure, the function of each subroutine in the model, and defines each variable used in the model. The TWOPAS model is written in FORTRAN and is intended to run on an IBM mainframe computer.

17. Key Words	18. Distribution Statement
Tow-lane highways Traffic operations Computer simulation Passing lanes	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	252	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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I. INTRODUCTION

A. Organization of Guide

This volume is the Programmer's Guide for the computer program TWOPAS, a microscopic simulation model of uninterrupted traffic flow on two-lane two-way highways with and without added passing lanes. This Introduction describes the need for the model, its history, the program approach, and features of interest to the user. Section II presents an overview of the TWOPAS program including the program structure, overall flow diagrams, the subroutine hierarchy and brief input/output file descriptions. Section III presents a series of special programming considerations that a programmer modifying the model should understand. Appendix A provides a detailed description of each subroutine in the TWOPAS model and Appendix B defines each variable used in COMMON. A companion volume, the TWOPAS User's Guide,[1] provides more detailed information on the input formats for geometric, traffic and vehicle data needed to run the TWOPAS model.

B. Need for Model/Program

The traffic flows on two-lane two-way rural highways are known or thought to be impacted by numerous variables associates with the highway geometrics, traffic controls, the vehicle population, and the driver population. Data from the field are essential to the study of these variables and their correlates. However, field data collection is expensive, is nearly always incomplete relative to some variables, and offers no opportunity to examine the traffic operational effects of systematic variations in traffic controls, geometrics, flow rates, vehicle mixes, and vehicle characteristics.

An analytical microscopic simulation model that contains a realistic account of geometrics, traffic controls, driver behavior, and vehicle characteristics can be used to study the impact of these variables under controlled conditions and without hazard or capital investment. 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. Consequently, the model is computerized to be practical.

The TWOPAS model may be used to simulate existing and projected future traffic operations on a highway section and to examine the traffic operational effects of proposed improvements to the highway including realignment, cross-sectional improvements, and addition of passing lanes in level and rolling terrain. These aspects of the model have been validated against traffic operational field data. The model also has the capability to simulate added climbing lanes on long, steep grades, but this capability has not been field validated.

C. Program History and Application

The following discussion reviews the history of the TWOPAS computer program and its major applications since its original development in the 1970's. The initial version of the computer program was developed by Midwest Research Institute (MRI) between 1971 and 1974 as part of the NCHRP, Project 3-19; the results of this study are presented in NCHRP Report 185, "Grade Effects on Traffic Flow Stability and Capacity."[2] The program, then known as TWOWAF, was originally developed to run on a Control Data Corporation (CDC) computer and was later modified to be compatible with an IBM compiler and operating system.

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-Berkeley, as part of the project, "A Decision-Making Framework for Evaluation of Climbing Lanes on Two-Lane Two-Way Rural Roads." The project was conducted by Professor Adolf D. May for the California Department of Transportation, and its results have been reported in the literature by Botha.[3]

The original TWOWAF program was also modified and applied by MRI in Contract No. DOT-FH-11-9434, "Implications of Light-Weight, Low-Powered Future Vehicles in the Traffic Stream."[4] The modified program was documented in 1981 under the contract in the volume, "Combined Users, Operations, and Program Maintenance Manual for TWOWAF, a Program for Microscopic Simulation of Two-Lane Two-Way Traffic."[5] 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. Another major addition made at this time was a capability for output of packed fuel consumption data for postprocessing in a fuel consumption model program also developed under the contract. The fuel model program was documented in 1983 in one volume as "Combined Users, Operations, and Program Maintenance Manual for a Computerized Model of Highway Vehicle Fuel Consumption."[6]

The revised TWOWAF model as modified above was employed by Texas Transportation Institute and KLD Associates in NCHRP Project 3-28A, "Two-Lane, Two-Way Rural Highway Capacity." TTI and KLD made further modifications. 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, no formal documentation is available. Pertinent information is contained in two working papers prepared during NCHRP Project 3-28A: "Analytical Framework for Evaluating Capacity and Level of Service for Two-Lane, Two-Way Rural Roads, Task 2 - Working Paper,"[7] and "Calibration and Validation of TWOWAF, Two-Lane, Two-Way Rural Road Computer Simulation Model, Task 3 - Working Paper."[8]

The TWOPAS model is an updated version of TWOWAF that incorporates the modifications and additions made in NCHRP Project 3-28A. There were four major additions: (a) capability to simulate passing and climbing lane sections; (b) entering traffic streams with user-specifiable percent of traffic platooned; (c) platoon leaders that are rationally selected to reflect the consequences of upstream geometrics; and (d) user-specifiable stations and subsections where spot data and overall data are collected. The ability of the model to simulate traffic operations in passing lane sections has been validated. This validation is presented in the FHWA report, "Operational Effectiveness of Passing Lanes."[9]

D. Program Approach and Features

The TWOPAS model simulates traffic operations on two-lane highways by reviewing the position, speed, and acceleration of each individual vehicle on a simulated roadway at 1-sec intervals and advancing those vehicles along the roadway in a realistic manner. The model takes into account the effects on traffic operations of road geometrics, traffic control, 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 added passing and climbing lanes on two-lane highways including the operation of the lane addition and lane drop transition areas and lane changing within the passing or climbing lane section. Spot data, space data, vehicle interaction data, and overall travel data are accumulated and processed, and various statistical summaries are printed.

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

Geometrics

- Grades
- Horizontal curves
- Lane width, shoulder width, and pavement quality
- Passing sight distance
- Passing and climbing lanes

Traffic Control

- Passing and no-passing zones
- Speed limits

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 each feature in the simulation model is described in the TWOPAS User's Guide.[1] The User's Guide includes a description of the input data needed to employ each of these features.

II. PROGRAM OVERVIEW

A. Program Description

1. Purpose: TWOPAS implements a microscopic traffic simulation model for uninterrupted flows on rural highways with a normal cross-section of two lanes for two-way flows. Capabilities include the addition of sections with added passing or climbing lanes in one or both directions. TWOPAS is normally exercised to evaluate traffic characteristics on a few miles of simulated highway. TWOPAS is written entirely in FORTRAN.

2. Relationship to other programs: The main program, TWOPAS, together with its set of 93 subroutines and functions, stands alone with one exception. The fuel consumption data, written on Unit 10, may be processed by the FORTRAN program FUELC. Documentation of FUELC is available from FHWA.[6] Otherwise, TWOPAS reads all input, exercises the simulation logic, and processes and prints all output from a simulation run.

3. Approach: There are three phases in a single application of the model: (a) data input and initialization, (b) simulation of traffic, and (c) output processing and printing. The main program, TWOPAS, controls all three phases by making appropriate transfers and calls to subroutines.

In the simulation phase, the program advances individual vehicles through successive 1-sec intervals, taking account of the road geometrics, traffic control, driver preferences, vehicle size and performance characteristics, and the oncoming and same direction vehicles. Spot data, space data, vehicle interaction data, and overall travel data are accumulated for final phase processing and output.

4. Programming assumptions: The program and its subroutines have been written with the length of the simulation review interval specified everywhere as a variable called DELT. However, the program has been used only with DELT equal to 1 sec. One facet of logic is tied to the value of DELT: the time for passers to vacate the opposing lane is fixed at two review periods.

5. Synopsis: The main program does a minor amount of initialization and tests for branching. For the most part, it calls subroutines that perform the major program functions of input, simulation, and output.

6. Programmers and dates: The original NCHRP/MRI version of the program TWOWAF was developed in 1971-1972. A majority of the simulation was programmed by Mr. A. D. St. John who also specified input and output contents and formats. The input and output routines were programmed by Mr. Ducan Sommerville who also encoded the simulation logic. Cross-section capabilities were restricted to one lane in each direction of travel. Descriptive documentation was included in NCHRP Report 185, "Grade Effects on Traffic Flow Stability and Capacity."[2]

A modification of the original version was prepared in 1979-1980. Mr. St. John programmed the revisions which were incorporated in the program by Mr. Calvin Bolze and Mr. Ronald Mast. The modification included the assembly, packing, and output of fuel consumption data. This aspect was programmed by Dr. W. D. Glauz. Cross-section capabilities in this version were still restricted to one lane in each direction. Documentation is also available for this earlier version of TWOWAF.[5]

Subsequently, the TWOWAF model was modified and employed by KLD Associates, in a subcontract to the Texas Transportation Institute in NCHRP Project 3-28A. KLD made several modifications including: a new car-following model with 10 driver types, elimination of driver work-load effects, and some adjustments to the pass acceptance probabilities and restraints. Mr. Reuben Goldblatt was the principal programmer of these modifications. Partial documentation of modifications appears in a working paper entitled "Calibration and Validation of TWOWAF, Two-Lane, Two-Way, Rural Road Computer Simulation Model."[8]

TWOPAS was developed from the version of TWOWAF as modified by KLD. The Pitt-KLD car-following model was replaced with a model which preserved the overall behavior of the 10 driver types, but which exhibited deceleration responses more appropriate for the actual risk involved. The capability for added passing or climbing lanes was incorporated using new field data and data from the literature on both two-lane and multilane traffic. The added passing or climbing lane logic was developed and programmed primarily by Mr. A. D. St. John. Provisions were added for accumulation and output of data for user-specified stations at spot locations and user-specified subsections of the simulated roadway. These additions were made and programmed primarily by Mr. Douglas W. Harwood. During final stages of debugging and the application of the program, it was converted for compatibility with an IBM system by FHWA staff, primarily Ms. Carol Conley.

B. Program Structure

As described above, TWOPAS can be viewed as having three major phases, although they do not appear explicitly in the subroutine organization. The three-phase structure of the program is illustrated by the flow diagram in Figure 1. Each phase of the program is briefly described below.

1. First phase: In the first phase of TWOPAS, the input data are read and processed for later use by the simulation logic. Figure 2 presents a flow diagram for the first phase of TWOPAS.

Four types of printed output are produced during the first phase of TWOPAS. The first type of output is a direct reflection of all input in an expanded card format. The second type of output provides vehicle characteristics, part of which are input and part are calculated performance capabilities. The third type of output includes the highway geometrics as organized for simulation processing, printed in a two-way, spatial-oriented format. The fourth type of output provides reference speeds for the simulation vehicles as if they were traveling alone on the specified alignment.

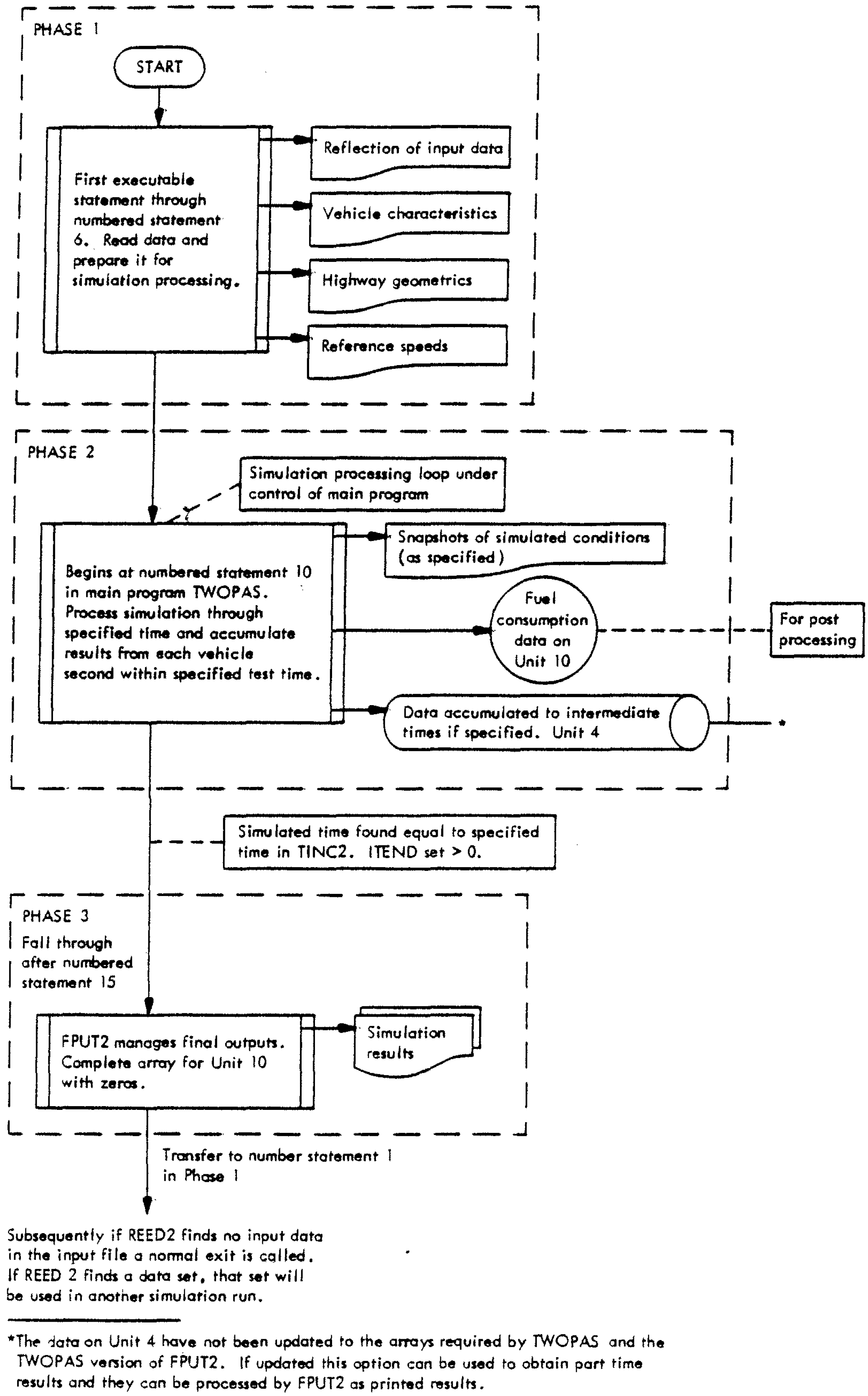

Figure 1 - Overall Flow Diagram of TWOPAS Illustrating Its Three-Phase Structure

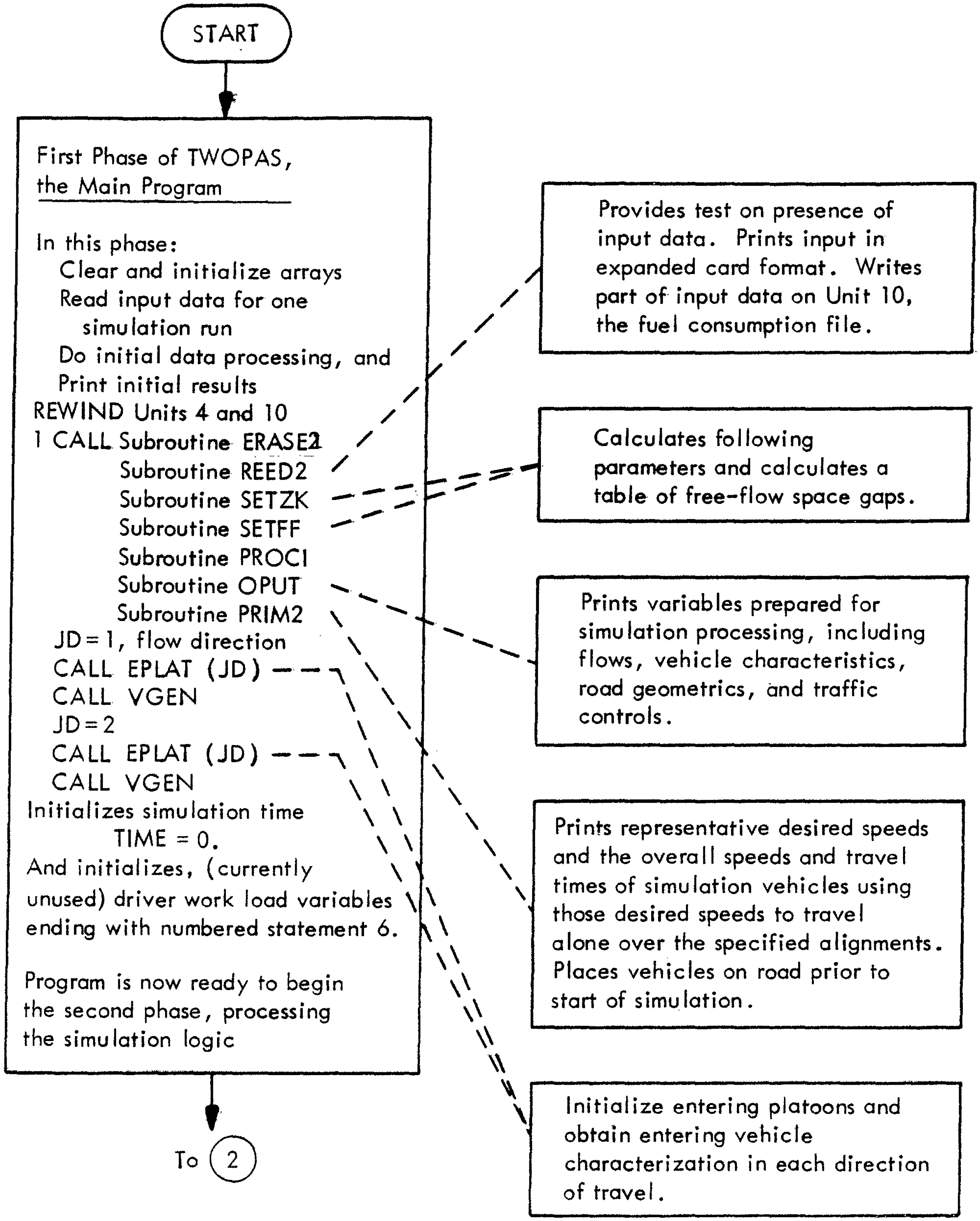

Figure 2 - Flow Diagram for First Phase of TWOPAS-Initiatization

The first phase of TWOPAS also primes the simulated roadway by placing simulation vehicles in initial states along the roadway prior to initiation of simulation processing.

2. Second phase: In the second phase of TWOPAS, the simulation logic is used repeatedly in separate applications to each vehicle on the highway to advance those vehicles through one review interval of simulation time. Figure 3 presents a flow diagram showing the overall structure for the second phase of TWOPAS.

During the second phase of TWOPAS, data are accumulated for vehicles within the user-specified highway sections (excluding buffer sections at each end of the simulated roadway) after an input specified warmup time has passed to exclude spurious unsteady effects at startup. Unless specified otherwise, data for each vehicle review are written to a file on Unit 10 for postprocessing to determine vehicle fuel consumption.

At user-specified simulation times, the status of all simulation vehicles on the road is printed in a special format known as a snapshot. Also, at user-specified times, accumulated data may be written on an intermediate file on Unit 4 for subsequent processing. However, the data written to Unit 4 has not been updated to include commons and arrays employed for roadway sections with added passing or climbing lanes. Therefore, the use of this feature is not recommended.

3. Third phase: In the third phase of TWOPAS, the data accumulated during the simulation run are processed and summaries are printed. After these summaries are printed, control is returned to Subroutine ERASE2, the first subroutine called in the main program. The subsequent path is determined by the remaining user input data on Unit 5 and the availability of data written to a file on Unit 4. The two possible outcomes at this point in processing are: (1) a new data set for an additional run may be read and processed; or (2) if the input file is empty, a normal exit is made. A simple flow diagram for the third phase of TWOPAS is presented in Figure 4.

C. Subroutine Hierarchy

The subroutine hierarchy for TWOPAS is illustrated in Figure 5. The figure illustrates the subroutines called by the main program and each subroutine, but the figure does not attempt to illustrate the sequential order of the subroutine calls in the program logic. A subroutine cross-reference is provided in Table 1.

A detailed description of each subroutine is found in Appendix A of this volume.

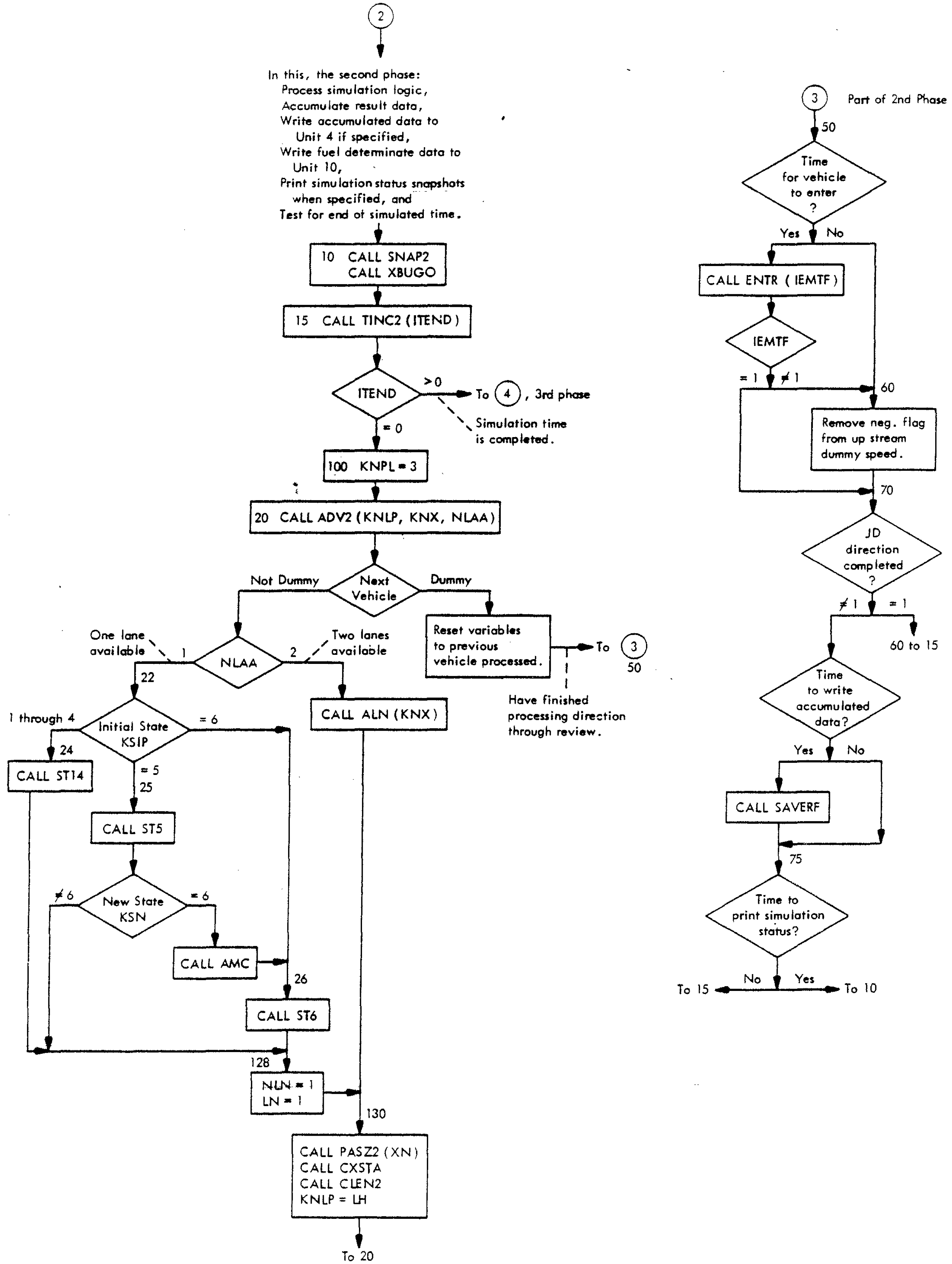

Figure 3 - Flow Diagram of Second Phase of TWOPAS-Simulation Processing

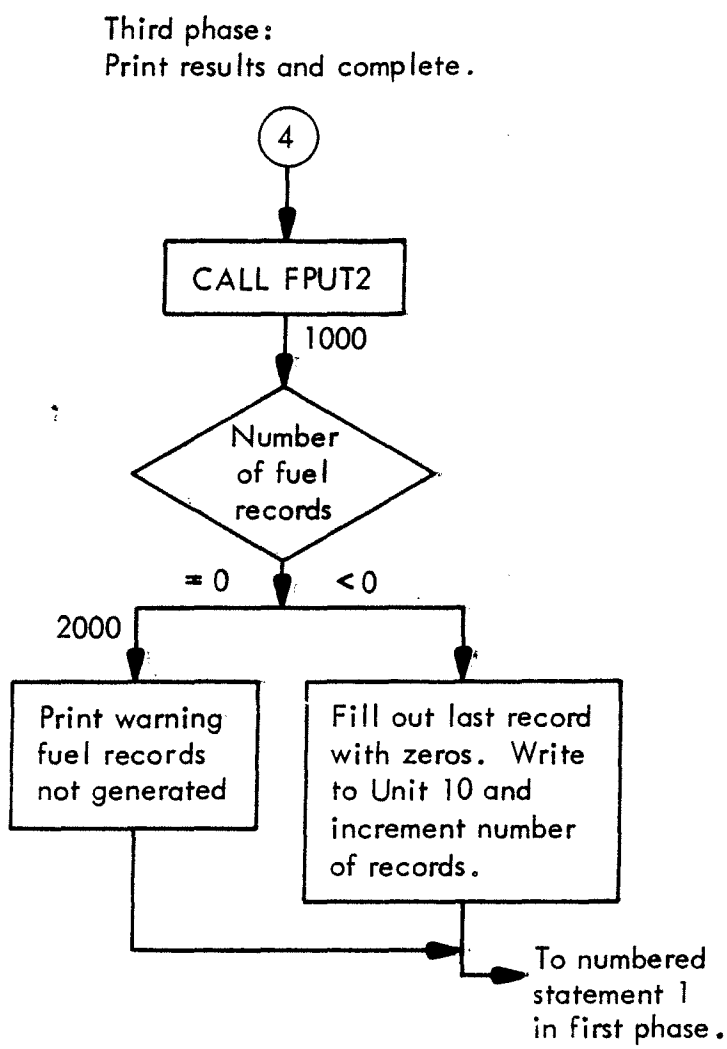

Figure 4 - Flow Diagram of Third Phase of TWOPAS-Final Processing of Output

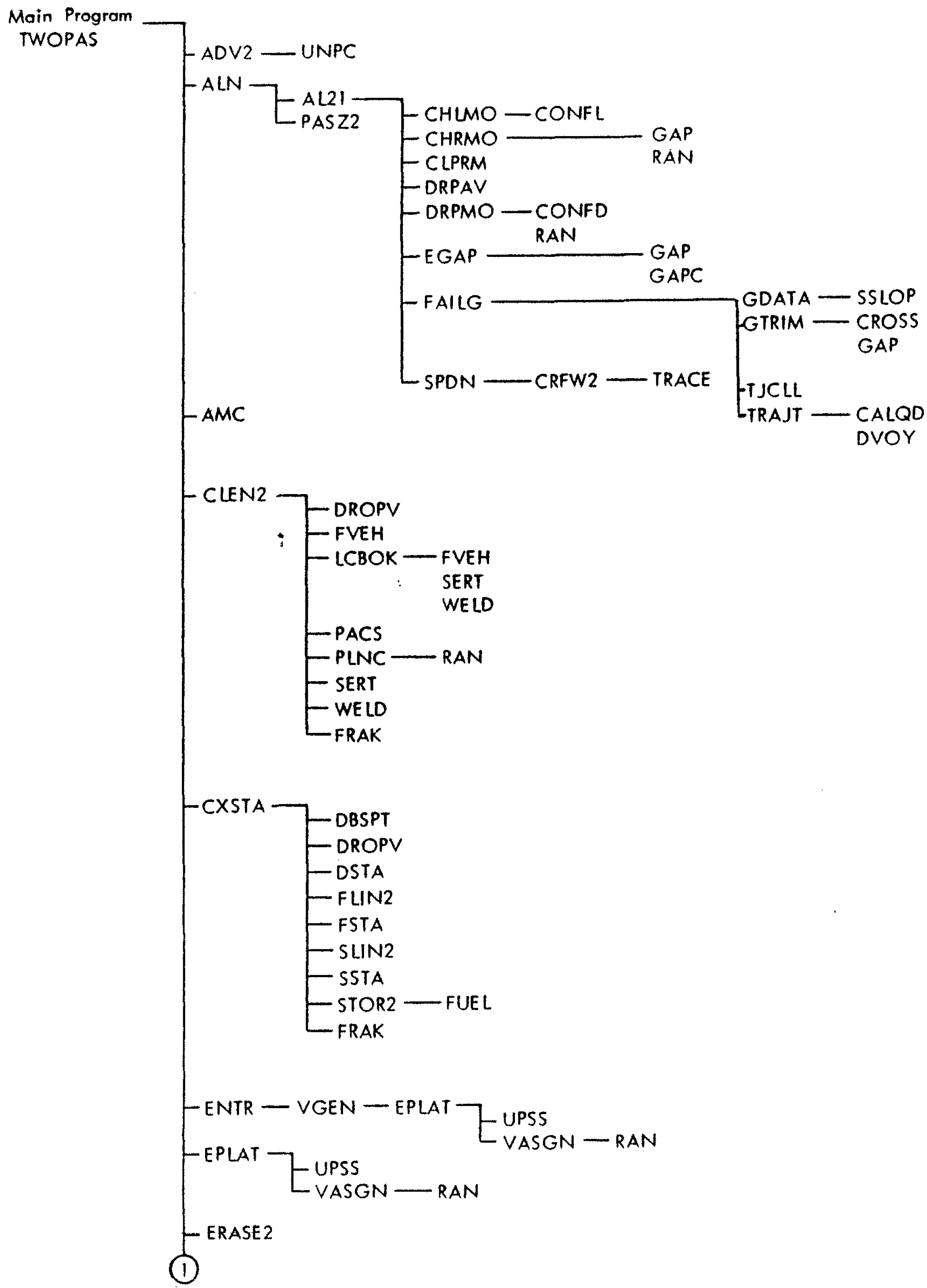

Figure 5 - Subroutine Hierarchy for TWOPAS

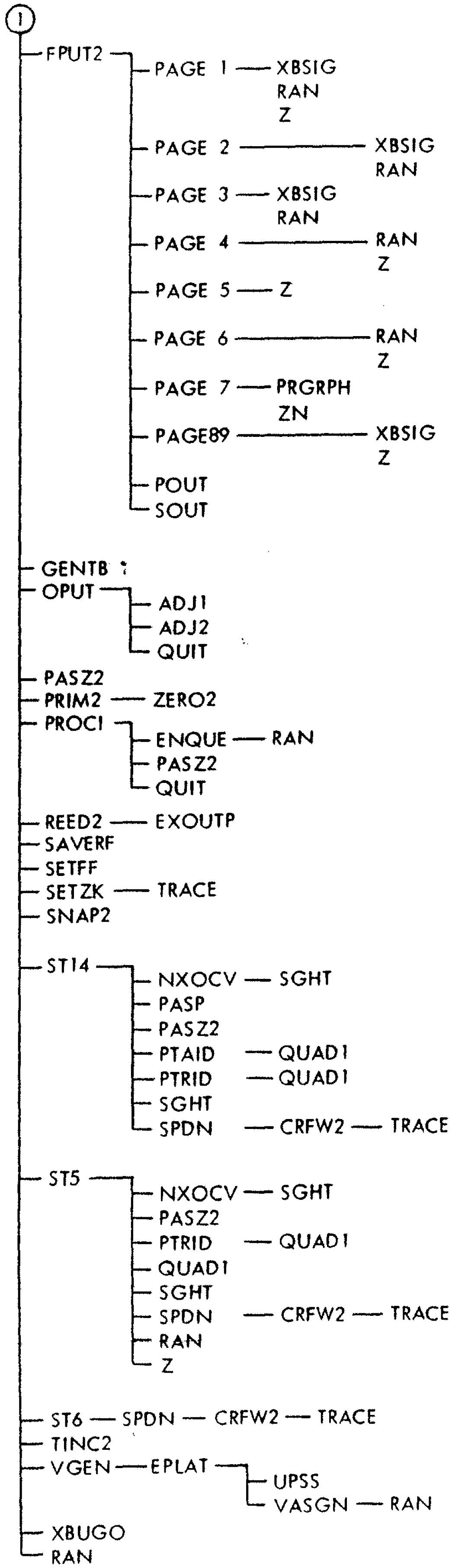

Figure 5 - (Concluded)

TABLE 1

SUBROUTINE CROSS-REFERENCE FOR TWOPAS

CALLED PROGRAM

CALLING PROGRAM	ADJ1	ADJ2	ADV2	ALN	AL21	AMC	CALQD	CHLMO	CHRMO	CLEN2	CLPRM	CONFD	CONFL	CRFW2	CROSS	CXSTA	DBSPT	DROPV	DRPAV	DRPMO	DSTA	DVOY	EGAP	ENQUE	ENTR	EPLAT	ERASE2	EXOUTP	FAILG	FLIN2	FPUT2	FSTA	FUEL	FVEH	GAP	GAPC	GDATA	GENTB	GTRIM	LCBOK	NXOCV	OPUT	PACS	PAGE 1	PAGE 2	PAGE 3	PAGE 4	PAGE 5	PAGE 6
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TABLE 1 (Continued)

CALLED PROGRAM

CALLING PROGRAM	ADJ1	ADJ2	ADV2	ALN	AL21	AMC	CALQD	CHLMO	CHRMO	CLEN2	CLPRM	CONFD	CONFL	CREW2	CROSS	CXSTA	DBSPT	DROPV	DRPAV	DRPMO	DSTA	DVOY	EGAP	ENQUE	ENTR	EPLAT	ERASE2	EXOUTP	FAILG	FLIN2	FPUT2	FSTA	FUEL	FVEH	GAP	GAPC	GDATA	GENTB	GTRIM	LCBOK	NXOCV	OPUT	PACS	PAGE 1	PAGE 2	PAGE 3	PAGE 4	PAGE 5	PAGE 6
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TABLE 1 (Concluded)

CALLED PROGRAM

CALLING PROGRAM	PAGE 7	PAGE 89	PASP	PASZ2	PLNC	POUT	PRGRPH	PRIM2	PROC1	PTAID	PTRID	QUADI	QUIT	REED2	SAVERF	SERT	SETFF	SETZK	SGHT	SLIN2	SNAP2	SOUT	SPDN	SSLOP	SSTA	STOR2	ST14	ST5	ST6	TINC2	TJCLL	TRACE	TRAJT	UNPC	UPSS	VASGN	VGEN	WELD	XBSIG	XBUGO	ZERO2	Function FRAK	Function RAN	Function Z	Function ZN
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D. COMMON Blocks

There are 103 COMMON blocks used in the main program and the various subroutines of TWOPAS, including 102 named COMMON blocks and one unnamed (/blank/) COMMON block. Table 2 provides a cross-reference indicating which COMMON blocks are used in the main program and each subroutine. The individual variables used in each COMMON block are defined in Appendix B of this volume.

E. Input/Output File Descriptions

The primary input data for TWOPAS is supplied in 80-column card-image records on FORTRAN Unit 5. The primary output data from TWOPAS are printed on Unit 6. The details of input data and printed output are described in the TWOPAS User's Manual.[1]

In addition to the above, the program writes to Unit 4 and may also read from Unit 4. The program writes only to Unit 10.

The data written to Unit 4 consists of all the accumulated data for a specific set of variables collected during the simulation test time that has been completed. The data transferred to/from Unit 4 consists of unformatted binary records containing the values of variables in the blank COMMON and COMMONs TIM, ROA, TOP, VEL, CAR, SMR, PCT, SCR, SPE and PAG. Zero to six such transfers may be made during one simulation. Note that these COMMONs do not contain updated data needed to determine traffic operations in added passing and climbing lane sections.

The data written to Unit 10 may be used by a subsequent program to determine vehicle fuel consumption. During simulation processing, Subroutine FUEL writes 128-element arrays as single records to Unit 10. The first records, written by Subroutine REED, contain data describing the simulation run. The last 128-element record, transferred by Subroutine FPUT2, is completed with zeros, if necessary. For all records after those written by Subroutine REED, each of the 128 array elements contains the packed data for one vehicle review period (normally 1 sec). The details of the packed data are described in Section III of this volume.

TABLE 2

COMMON Block Cross-Reference for TWOPAS

COMMON

PROGRAM OR SUBROUTINE	AAMN	ADJ	AEOL	AKPM	ALL	BKPM	/blank/	BSPOT	CAR	CARA	CHOZL	CMTOUT	COND	CV	CW	DIM	DRPL	DSV	EP	EPR	EXT	FHP	FUL	GD	GDAT	GEN	GEO
MAIN PROGRAM				●		●	●		●										●			●	●			●	
BLOCK DATA		●			●	●			●		●			●	●	●	●		●		●	●		●		●	●
ADJ1		●																			●						
ADJ2		●																			●						
ADV2									●	●				●	●			●	●					●			●
ALN									●																		
AL21	●								●																		
AMC									●												●						
CALQD																											
CHLMO									●	●																	
CHRMO									●	●																	
CLEN2									●	●									●		●		●				
CLPRM			●						●																		
CONFD									●	●			●														
CONFL									●	●																	
CRFW2																											
CROSS																											
CXSTA									●																		
DBSPT								●	●	●																	
DROPV									●												●						
DRPAV									●								●										
DRPMO									●				●				●										
DSTA									●																		
DVOY																											
EGAP									●	●																	
ENQUE						●																					
ENTR					●				●																	●	
EPLAT																											
ERASE2							●	●																			
EXOUTP							●		●																		
FAILG							●		●	●															●		
FLIN2							●		●																		
FPUT2							●					●															
FSTA								●	●																		
FUEL									●														●				
FVEH																											
GAP																											
GAPC																											
GDATA									●																●		
GENTB						●																					
GTRIM									●																●		
LCBOK									●	●																	
NXOCV									●																		●
OPUT		●							●					●	●						●			●			
PACS																											
PAGE 1							●																				
PAGE 2							●																				
PAGE 3							●																				
PAGE 4							●																				
PAGE 5							●																				
PAGE 6																											

PROGRAM OR SUBROUTINE	IDRT	I7SPD	INI	IPTAR	KATPL	KTES	LNCH	MMXF	NLANS	NOV	NVSIZ	NX	OO	PAG	PAS	PCT	PCTOUT	PE	PLAT	PLD	PLHDWY	PMOUT	PPT	PS	QUA	RAMAX
MAIN PROGRAM							●								●		●		●					●		
BLOCK DATA			●								●		●		●	●					●			●	●	●
ADJ1																										
ADJ2																										
ADV2							●																			
ALN	●						●								●											
AL21				●			●								●											
AMC																										
CALQD																										
CHLMO							●																		●	
CHRMO							●																		●	
CLEN2							●								●		●							●	●	
CLPRM							●								●									●	●	
CONFD																										
CONFL																										
CRFW2																										●
CROSS																										
CXSTA						●	●					●														
DBSPT							●																	●		
DROPV																										
DRPAV																								●		
DRPMO							●								●									●		
DSTA					●	●	●		●												●					
DVOY																										
EGAP							●	●																●		
ENQUE																										
ENTR															●				●							
EPLAT																			●							
ERASE2					●																					
EXOUTP														●		●										
FAILG				●			●	●																●	●	
FLIN2							●														●					
FPUT2							●		●						●		●					●				
FSTA																										
FUEL																										
FVEH																										
GAP							●																			
GAPC																										
GDATA				●																						
GENTB																										●
GTRIM							●																	●		
LCBOK							●																			
NXOCV										●					●										●	
OPUT			●												●									●		
PACS																										
PAGE 1																●										
PAGE 2														●		●										
PAGE 3														●		●										
PAGE 4																●										
PAGE 5																●										
PAGE 6																●						●				

TABLE 2 (Continued)

COMMON

PROGRAM OR SUBROUTINE	RE	REG	REGA	REUB1	REUB2	REUB3	RNS	ROA	RTTBS	RVMAX	SAVOUT	SCR	SMR	SPE	SPOT	ST	STA	STAT	SWT	TAB	TIM	TOP	TRK	TTIOUT	TTMOUT	TTSOUT	TVIN	UND
MAIN PROGRAM						●		●						●				●	●		●							
BLOCK DATA	●	●				●	●	●		●			●	●		●	●				●		●					
ADJ1																												
ADJ2																												
ADV2		●	●					●																				
ALN																					●							
AL21		●																										
AMC																	●				●							
CALQD																												
CHLMO		●	●																									
CHRMO		●	●																									
CLEN2		●	●	●				●													●							
CLPRM	●																				●							
CONFD		●	●																		●							
CONFL		●	●																		●							
CRFW2										●																		
CROSS																												
CXSTA								●										●			●							
DBSPT			●					●													●							
DROPV		●						●																				
DRPAV																												
DRPMO																												
DSTA		●						●							●			●			●							
DVOY																												
EGAP			●					●													●							
ENQUE								●						●							●							
ENTR								●													●							
EPLAT																												
ERASE2									●				●		●						●							
EXOUTP								●				●	●	●							●	●						
FAILG		●	●																		●							
FLIN2								●					●					●			●						●	
FPUT2								●			●							●			●	●		●	●	●		●
FSTA																					●						●	
FUEL								●																				
FVEH		●		●																								
GAP																				●								
GAPC																												
GDATA																					●							
GENTB						●				●										●								
GTRIM																												
LCBOK		●	●																									
NXOCV								●													●							
OPUT								●					●	●		●					●	●	●					
PACS																												
PAGE 1								●			●	●	●	●							●							●
PAGE 2								●				●	●	●							●			●	●	●		●
PAGE 3								●				●	●	●														●
PAGE 4												●	●									●						●
PAGE 5												●																
PAGE 6								●				●																●

PROGRAM OR SUBROUTINE	UPE	VC	VEH	VEL	VIC	XCOUNT	XHEAD	XHMAX	XNLP	XPPL	YTRACE	ZER	ZFFX	ZK	ZKCOR	ZKF	ZKJ	ZL	ZM	ZPASPL	ZUF	ZVC
MAIN PROGRAM			●			●																
BLOCK DATA	●	●	●	●	●		●	●	●			●	●	●		●	●	●	●		●	●
ADJ1			●																			
ADJ2			●																			
ADV2			●																			
ALN			●																			
AL21		●			●																	
AMC		●	●																			
CALQD																						
CHLMO																						
CHRMO				●																		
CLEN2			●	●																		
CLPRM																						
CONFD			●																			
CONFL			●																			
CRFW2											●			●								●
CROSS																						
CXSTA																						
DBSPT																						
DROPV			●																			
DRPAV																						
DRPMO																						
DSTA			●																			
DVOY																						
EGAP		●	●																			
ENQUE		●				●	●	●		●				●						●		
ENTR		●	●	●		●	●						●									
EPLAT		●				●	●					●										
ERASE2																						
EXOUTP				●																		
FAILG			●																			
FLIN2			●	●																		
FPUT2																						
FSTA																						
FUEL			●																			
FVEH																						
GAP																						
GAPC																						
GDATA		●	●																			
GENTB											●			●								●
GTRIM																						
LCBOK			●																			
NXOCV		●	●																			
OPUT		●	●	●																		
PACS			●																			
PAGE 1				●																		
PAGE 2				●																		
PAGE 3				●																		
PAGE 4																						
PAGE 5																						
PAGE 6																						

TABLE 2 (Continued)

COMMON

PROGRAM OR SUBROUTINE	AAMN	ADJ	AEOL	AKPM	ALL	BKPM	/blank/	BSPOT	CAR	CARA	CHOZL	CMTOUT	COND	CV	CW	DIM	DRPL	DSV
PAGE 7							●											
PAGE 89							●											
PASP									●									
PASZ2									●									
PLNC									●		●							
POUT																		
PRGRPH																		
PRIM2									●					●	●			
PROCI						●	●							●	●	●		
PTAID									●									
PTRID									●									
QUADI																		
QUIT																		
REED2						●						●		●	●			
SAVERF							●		●									
SERT																		
SETFF																		
SETZK																		
SGHT																		
SLIN2							●		●									
SNAP2																		
SOUT								●										
SPDN			●	●	●				●									
SSLOP																		
SSTA									●									
STOR2							●		●									
ST14									●									
ST5									●									
ST6									●									●
TINC2									●	●				●	●			
TJCLL									●									
TRACE																		
TRAJT	●								●									
UNPC																		
UPSS																		
VASGN									●									
VGEN				●		●			●									
WELD																		
XBSIG																		
XBUGO																		
ZERO 2				●		●			●					●	●			
Function FRAK																		
Function RAN																		
Function Z																		
Function ZN																		

PROGRAM OR SUBROUTINE	EP	EPR	EXT	FHP	FUL	GD	GDAT	GEN	GEO	IDRT	I7SPD	INI	IPTAR	KATPL	KTES	LNCH	MMXF	NLANS
PAGE 7																		
PAGE 89																		
PASP																		
PASZ2																		
PLNC																		
POUT																		
PRGRPH																		
PRIM2						●			●		●	●						
PROCI		●	●	●		●		●				●						●
PTAID																		
PTRID									●									
QUADI																		
QUIT																		
REED2		●		●	●	●												
SAVERF																		
SERT																		
SETFF																		
SETZK																		
SGHT																		
SLIN2																●		
SNAP2	●		●															
SOUT																		
SPDN	●		●	●					●							●		
SSLOP							●									●		
SSTA																		
STOR2					●							●				●		
ST14			●						●									
ST5			●									●						
ST6	●		●									●						
TINC2						●			●			●			●			
TJCLL							●									●		
TRACE																		
TRAJT							●						●					
UNPC																●		
UPSS																		
VASGN																		
VGEN								●		●								
WELD																		
XBSIG																		
XBUGO																		
ZERO 2			●	●		●			●	●	●	●						
Function FRAK																		
Function RAN																		
Function Z																		
Function ZN																		

PROGRAM OR SUBROUTINE	NOV	NVSIZ	NX	OO	PAG	PAS	PCT	PCTOUT	PE	PLAT	PLD	PLHDWY	PMOUT	PPT	PS	QUA	RAMAX
PAGE 7							●										
PAGE 89							●										
PASP						●								●			
PASZ2						●									●		
PLNC																	
POUT																	
PRGRPH																	
PRIM2															●		
PROCI		●				●			●						●		
PTAID						●										●	
PTRID																●	
QUADI																●	
QUIT																	
REED2				●		●									●		
SAVERF					●		●										
SERT																	
SETFF																	●
SETZK																	
SGHT						●											
SLIN2												●					
SNAP2		●															
SOUT						●									●		
SPDN						●										●	
SSLOP																	
SSTA																	
STOR2																	
ST14						●								●	●	●	
ST5	●					●										●	
ST6																	
TINC2	●		●												●		
TJCLL						●									●		
TRACE																	
TRAJT																●	
UNPC																	
UPSS																	
VASGN																	
VGEN										●							
WELD																	
XBSIG																	
XBUGO																	
ZERO 2						●										●	
Function FRAK																	
Function RAN																	
Function Z																	
Function ZN																	

TABLE 2 (Concluded)

PROGRAM OR SUBROUTINE	RE	REG	REGA	REUB1	REUB2	REUB3	RNS	ROA	RTTBS	RVMAX	SAVOUT	SCR	SMR	SPE	SPOT	ST	STA	STAT	SWT	TAB	TIM	TOP	TRK	TTIOUT	TTMOUT	TTSOUT	TVIN	UND	UPE	VC	VEH	VEL	VIC	XCOUNT	XHEAD	XHMAX	XNLP	XPPL	YTRACE	ZER	ZFFX	ZK	ZKCOR	ZKF	ZKJ	ZL	ZM	ZPASPL	ZUF	ZVC
PAGE 7												●																																						
PAGE 89								●				●	●								●																													
PASP																																	●																	
PASZ2								●																																										
PLNC								●						●																																				
POUT															●			●			●																													
PRGRPH												●																																						
PRIM2								●					●	●							●	●									●	●								●										
PROC1								●					●	●		●		●			●		●							●	●	●		●	●	●						●						●		
PTAID								●													●									●	●		●																	
PTRID																	●													●		●	●							●										
QUADI																																																		
QUIT																																																		
REED2							●	●					●	●		●		●	●		●	●	●						●	●	●	●						●					●							
SAVERF								●				●	●	●							●	●										●																		
SERT																															●																			
SETFF										●																													●		●	●								
SETZK																																							●			●	●	●	●	●	●		●	
SGHT								●								●																																		
SLIN2								●										●			●						●				●																			
SNAP2								●													●										●	●																		
SOUT									●				●	●				●			●																													
SPDN					●	●											●				●									●	●	●	●								●									
SSLOP																				●																														
SSTA																					●						●																							
STOR2								●					●								●												●																	
ST14		●		●	●			●									●				●									●	●	●	●															●		
ST5		●		●	●			●									●				●									●	●	●	●																	
ST6								●													●									●	●		●																	
TINC2		●	●	●				●								●		●			●										●																			
TJCLL		●																			●									●	●																			
TRACE																																							●											
TRAJT																					●																													
UNPC																																																		
UPSS																													●			●																		
VASGN																																●								●										
VGEN								●						●							●		●				●				●			●	●					●										
WELD																															●																			
XBSIG																																																		
XBUGO																					●										●																			
ZERO2								●	●				●	●				●			●						●			●	●	●								●										
Function FRAK																																																		
Function RAN							●																																											
Function Z																																																		
Function ZN																																																		

III. SPECIAL PROGRAMMING CONSIDERATIONS

This section describes special features in the TWOPAS model that are of interest to programmers. The following features are described in the indicated subsection.

A. Directions of Travel and Coordinate Systems
B. Organization of Highway Characteristics Data
C. Limits on Highway Characteristics Data
D. Test Time and Test Length
E. Units
F. Vehicle Types, Categories, and Directional Forms
G. States and Stages of Simulation Vehicles
H. Processing Sequence and Associated Pointers
I. The Regional Table, Special Data Forms for Vehicles in Process
J. Priming and Reference Speeds
K. Driver Work Load Logic
L. Packed Data
M. Fuel Consumption Data
N. Random Numbers and Their Use in Related Runs
O. Temporary Flags

A. Directions of Travel and Coordinate Systems

TWOPAS makes provision for traffic entering and traveling along the simulated roadway in two directions, referred to as Directions No. 1 and No. 2. Direction of travel is frequently used as an array subscript, usually JD.

The position coordinate for Direction No. 1 is zero at one end of the simulated roadway and extends to RL feet. Likewise, the Direction No. 2 coordinate is zero at the other end of the simulated roadway and extends in the opposite direction to RL feet. During simulation processing, the locations of vehicles are in terms of the directional coordinate system for their own particular direction of travel.

To avoid confusion to users, the Direction No. 1 coordinate system is employed exclusively in input data defining the geometrics and traffic control features of the simulated roadway. This consistency is maintained even for features which have an exclusively Direction No. 2 sense. That is, the location of the beginning of a passing zone in Direction No. 2 is specified in Direction No. 1 coordinates but is recognized by the model as the beginning of the zone in the Direction No. 2 sense. This approach allows input data to be developed easily from highway agency records kept in milepost or stationing systems.

Initial processing of the input data by Subroutine PROCI converts all pertinent geometric and traffic control data to the appropriate directional coordinate system for each direction of travel. These directionally rectified data are used during simulation processing.

B. Organization of Highway Characteristics Data

The highway characteristics used in the TWOPAS model are position and direction dependent and include: (a) vertical grade, (b) passing sight distance, (c) passing zones, no-passing zones, and added passing or climbing lanes, (d) the effects of horizontal curvature on desired speed and on pass acceptance, and (e) crawl regions where trucks use low speeds on sustained downgrades.

Subroutine PROCI processes the user-supplied input data and default data on highway characteristics in preparation for use during the simulation. Subroutine PROCI places these data in the proper form and under the proper variable name needed for simulation processing. During the simulation processing, the data for each characteristic are treated separately, but the general organization is similar for all.

The data for a particular highway characteristic consist of subscripted arrays where one subscript applies to a specific position-direction of travel combination, or region. (The region boundaries for different highway characteristics are independent of one another and need not necessarily coincide.) For any location, the value of the highway characteristic of interest can be calculated as a linear or quadratic function of position with a subscripted set as coefficients. The subscript sequence starts with 1 at the upstream end of Direction No. 1 and increases toward the downstream end. The subscript sequence then continues at the upstream end of Direction No. 2 and increases toward the downstream end in that direction of travel.

For the simulation processing logic, all highway characteristics (or their effects) are defined everywhere in both directions along the simulated road. In the case of sight distance, a small value provided as input by the user will be replaced by a user-specified minimum value, SMIN, whenever SMIN is larger.

The ranges of subscripts in use are available in symbol names as shown in Table 3, together with other names and information.

C. Limits on Highway Characteristics Data

The limits on the amount of highway characteristics data arise from variable dimensions that restrict the number of regions available for each characteristic. Further, for some characteristics, the program logic adds essential regions in addition to those specified by user input. Table 4 presents the maximum number of features that can be safely specified and shows the basis for the maxima.

D. Test Time and Test Length

Two times to be simulated are specified in minutes by the user for each simulation run, a warmup time (TWRM) and a test time (TTES). The simulation is exercised for time TWRM without collecting data and then for an additional time TTES during which data are collected.

TABLE 3

VARIABLES FOR HIGHWAY CHARACTERISTICS DATA IN THE FORM DURING SIMULATION

Characteristic	Names for Subscript Ranges, Direction JD: Upstream	Names for Subscript Ranges, Direction JD: Downstream	Variables for Coefficients of Characteristic or Effects, Region NN: Constant	Variables for Coefficients of Characteristic or Effects, Region NN: Linear Position	Variables for Coefficients of Characteristic or Effects, Region NN: Square of Position	Variable for Upstream End of Region NN Directional Coordinate (ft)	Maximum No. of Regions (Based on Dimensions)	Input	Default
Grade	NJGD(JD)	MJGD(JD)	G0(NN)	G1(NN)[a]	-	XGDN(NN)	60	All[f]	All 0%
Passing sight distance	NLS(JD)	MLS(JD)	SGTO(NN)	RST(NN)[b]	-	XSGO(NN)	60	Partial[g]	All SNOM
Passing zones, no-passing zones, and added passing or climbing lanes	NLP(JD)	MLP(JD)	JPS(NN) (-1,0,1,2,3)	-	-	XPZO(NN)	60	All[h]	100% passing zones (+1)
Horizontal curve effects	NJCV(JD)	MJCV(JD)	CV0(NN)	CV1(NN)[c]	CV2(NN)[d]	XCVN(NN)	60	Curves[i] for Direction No. 1	Tangent
Downgrade crawl region effects	NJCW(JD)	MJCW(JD)	CW0(NN)	CW1(NN)[c]	CW2(NN)[e]	XCWN(NN)	40	Crawl[j] regions only	No crawl regions

[a] The linear term uses for position the downstream displacement from the beginning of the region at XGDN(NN); i.e., XIP-XGDN(NN).

[b] The linear expression uses for position the downstream displacement from the beginning of the region at XSGO(NN); i.e., XIP-XSGO(NN).

[c] The linear and quadratic terms use the directional position coordinates with origins at the upstream end of the simulation road.

[d] The quadratic expression supplies curve-limited desired mean speed as function of position where position is directional position with origin at directional upstream end. An associated variable RCV(NN) supplies the ratio (desired speed standard deviation due to curve/the standard deviation of nromal desired speed).

[e] The quadratic expression supplies crawl-limited desired mean speed as a function of position where position is direction position with origin at the directional upstream end. An associated variable RCW(NN) supplies the ratio (desired speed standard deviation due to crawl/standard deviation of normal desired speed).

[f] If any grade data are supplied, entire simulation road length must be defined in Direction No. 1 by the user.

[g] At position-direction of travel combinations where sight distance is not supplied, program logic inserts regions of constant sight distance, SNOM.

[h] If any passing zone data are supplied, entire road length in both directions of travel must be defined by the user.

[i] Curves are specified by input in Direction No. 1 only. Program logic defines approach regions for horizontal curves and intervening tangent regions for both directions of travel.

[j] Regions in both directions of travel where trucks need crawl speeds, and the associated crawl speed data are provided in user-specified input. The program logic defines approach regions and intervening regions where there are no crawl constraints.

TABLE 4

MAXIMUM LIMITS ON AMOUNT OF HIGHWAY CHARACTERISTICS DATA

Characteristic	Input: Regions Specified	Input: Maximum	Total Regions Potentially Used Per Input Region	Regions Potentially Assigned at Ends of Simulation Road	Number of Regions Dimensioned
Grade	For entire road length in Direction No. 1	30 (Direction No. 1 only)	2[c]	0	60
Passing sight distance	Any road lengths in both directions	28[a] (Both directions combined)	2[d]	2	60
Passing zones, no-passing zones, and added passing or climbing lanes	For entire road length in both directions	60 (Both directions combined)	1	0	60
Horizontal curve effects	For nontangent lengths only in Direction No. 1	9[b] (Direction No. 1 only)	6[e]	2	60
Downgrade crawl region effects	For lengths in both directions on which trucks need to use crawl speeds	12 (Directions combined)	3[f]	2	40

[a] Many more than 28 regions usually can be assigned. It is necessary to recognize that program logic will add a region of constant sight distance SNOM between any two specified regions that are not contiguous. If the entire road length (both directions) is specified, all 60 regions can be used in input specifications. The implementation of a minimum sight distance SMIN is made during simulation processing and does not affect region capacity.

[b] A larger number of specified curves may be acceptable if some of the related regions are not needed (see Note e). However, this is not certain a priori.

[c] The second region is for the same grade data in Direction No. 2.

[d] The second region is for the adjacent intervening road length, which may potentially be supplied by program logic.

[e] For each curve specified in Direction No. 1, an upstream approach region and a downstream region of no curve effect may be needed. This same trio of regions is needed for Direction No. 2. However, if the curve does not affect speeds, the approach region will be combined with the curve proper. Proximity of curves may also eliminate the need for some of the added regions.

[f] For each specified crawl region, an approach region may be required; and downstream, a region of no crawl effect may be required.

In addition to the user-specified road length, RL, buffer lengths are expected for each direction of travel at the upstream and downstream ends of the simulated roadway. In TWOWAF, these lengths were all equal, and were specified as XBUF in input. In TWOPAS, the entrance buffer length for direction one extends from 0 to XSTA(1,1), the user-specified location of the most upstream data collection station for Direction No. 1. The Direction No. 1 exit buffer extends from XSTA(MX,1) to RL, where MX = MSTA(1) is the largest data collection station number specified for Direction No. 1. Likewise, for Direction No. 2 during simulation processing, the entrance buffer extends from 0 to XSTA(1,2) and the exit buffer extends from XSTA(MX,2) to RL in Direction No. 2 coordinates, where MX = MSTA(2). However, it should be recognized that input station positions for Direction No. 2 are specified by the user in Direction No. 1 coordinates. The conversion to the appropriate directional coordinates for Direction No. 2 is done in Subroutine PROCI.

For descriptive convenience, the XSTA(1,1) is considered the "start line" and XSTA(MX,1) the "finish line" for traffic in Direction No. 1. Similarly, for traffic in Direction No. 2, the start and finish lines are located at XSTA(1,2) and XSTA(MX,2), respectively. Overall data from the simulation are collected and output for the entire roadway between the start and finish lines in each direction of travel.

E. Units

Internally, the simulation works with length in feet and time in seconds, so that speeds are expressed in ft/sec and all accelerations are expressed in ft/sec^2. Also, some test values and equation coefficients are dimensional so that an arbitrary selection of revised input and output interpretation would not suffice to change units. For the most part, the output also uses units of feet and seconds.

For convenience, a few output items are converted to miles and hours; for example, pass initiations per veh-mile and per lane-mile-hr.

The input data for trucks requires the weight/net horsepower ratio. Here, weight is expressed in pounds and net horsepower in the English system (i.e., one horsepower equal to 33,000 ft-lb/hr). Also for trucks, the weight/projected frontal area ratio is expressed at lb/ft^2.

Certain other input data also sacrifices consistency for conventional practice. The length of a simulation run is specified in minutes, while flow rates are expressed in veh/hr.

Horizontal curve data include location of the point of curvature (ft, in Direction No. 1 sense and coordinates), curve radius (ft), and total heading change (degrees). Initial processing converts the user-specified curve data to termini locations in feet. Grades are specified in percent at user-selected locations. The user-specified data are processed to obtain the initial percent and rate of change in %/ft for each grade region.

F. Vehicle Types, Categories, and Directional Forms

Provision is made for 13 vehicle types that are classified into three categories as follows:

Category	Vehicle Category Subscript	Vehicle Type Subscript
Trucks (including buses)	1	1 2 3 4
Recreational vehicles (RVs)	2	5 6 7 8
Passenger cars (including light trucks, pickups and vans)	3	9 10 11 12 13

Each vehicle category is composed of 4 or 5 vehicle types whose length and performance capabilities can be specified independently.

During simulation processing, some branching is made on the basis of vehicle category. For example, trucks (Category 1) employ criteria for maximum acceleration that are distinct from those employed for RVs and passenger cars. Unless a default is overridden, only trucks use crawl speeds to descend steep, extended grades. Also, a truck engaged in a passing maneuver, unlike an RV or a passenger car, deters its follower from starting a passing maneuver around the same impeder.

Data are collected during simulation and are subsequently processed by individual vehicle types and categories, and most often by direction of travel as well. For convenience, the vehicle type or category designation is often combined with direction of travel to form a single subscript for a one-dimensional array. For example, the combined subscripts for vehicle type and direction range from 1 through 26, with subscripts 1 through 13 for Direction No. 1 and subscripts 14 through 26 for Direction No. 2. Similarly, the range for combined subscripts for vehicle category and direction of travel is 1 through 6.

Eight "dummy vehicles" are used in the program logic. They are assigned as vehicle type 13, but are identified as dummies because of their subscripts (1 through 8). The dummies are located 400 ft beyond the downstream ends and 50 ft upstream of the entrance ends of the simulated roadway. These vehicles are not processed, but serve special purposes in controlling the simulation logic.

G. States and Stages of Simulation Vehicles

The state of a simulation vehicle is carried in subscripted data as KS(I), where I is subscript or vehicle index that identifies a particular vehicle. For a vehicle in process, the initial state at the beginning of a vehicle review interval is stored in the variable KSIP. A new state, KSN, determined by the processing logic, may or may not differ from KSIP. There are six states as follows:

1 - Free vehicle, unimpeded by other vehicles in the same lane.

2 - Overtaking leader in the same lane but still at speed more than 8 ft/sec faster.

3 - Following a leader in the same lane.

4 - Following a leader in the same lane, when the vehicle in process has a desired speed and acceleration capability that is consistent with an interest in passing.

5 - Passing another (same direction) vehicle in a maneuver that uses an opposing direction lane.

6 - Aborting a passing maneuver which uses an opposing direction lane.

Only vehicles in sections with one lane in their direction of travel can be in states 5 or 6. ("Passing" by vehicles in added passing or climbing lanes does not involve the state 5 or 6 situations.)

In states 5 and 6, extra data describing the stage of the passing maneuver are required. The subscript, IDEX, for these extra data is packed in KS(I). The extra data include ISTG(IDEX), the stage of the maneuver, which has the following values and meanings:

Maneuver	ISTG	Meaning
Passing (State 5)	1	Not committed to complete pass.
	2	Committed to complete pass (i.e., would pull ahead of other vehicle even if large deceleration were used.)
	3	Ahead of impeder (measured nose to nose).
	4	Clear of impeder and making decision about passing another vehicle, if any.
	5	Clear of impeder, not extending pass, and has two review periods before vacating the opposing-direction lane.
	6	Clear of impeder and has one review before vacating the opposing-direction lane.

Maneuver	ISTG	Meaning
Aborting pass (State 6)	1	Acquiring relative position to begin return to normal lane.
	2,3,4	Not used.
	5	Clear of impeder and has two review periods before vacating the opposing-direction lane.
	6	Clear of impeder and has one period before vacating the opposing-direction lane.

H. Processing Sequence and Associated Pointers

In processing through a review interval during the simulation, the Direction No. 1 vehicles are processed first; then, the Direction No. 2 vehicles are processed. In processing of each vehicle, a new position, speed, and acceleration for each vehicle is determined based on its current position, speed, and acceleration relative to other vehicles, the performance limitations of the vehicle and driver preferences. The vehicle is then advanced to its new position. In processing each vehicle, careful bookkeeping is required to keep track of whether each surrounding vehicle has or has not been advanced yet in the current review interval. When processing a Direction No. 2 vehicle for pass or abort decisions, potentially conflicting Direction No. 1 vehicles must be extrapolated backward in time to determine their actual position relative to the Direction No. 2 vehicle.

Vehicles are processed starting at the downstream end of the simulated roadway in each direction of travel and working upstream. Where there is an added passing or climbing lane in the direction being processed, the next vehicle to be processed is the unprocessed vehicle farthest downstream without regard to the lane occupied. In a tie, the vehicle in the left lane (generic lane 1) is processed first. All processing is completed in one sweep. Thus, in a single directional sweep, all vehicles in that direction are completely processed without exception.

As a result of the processing sequence, leader-follower interactions within a given lane involve a leader that has been advanced by the simulation. The leader is extrapolated backward in time to obtain approximate start-of-review conditions.

The sequence of the vehicles in each lane is established by use of a set of pointers and dummy vehicles. All conventional data associated with a specific vehicle are available through the subscript or vehicle index assigned to it when the vehicle is generated. The data for each simulation vehicle include two pointers with symbol names and meanings as follows:

LD(I) - subscript of same lane leader of the vehicle with subscript I.

LG(I) - subscript of same lane follower of the vehicle with subscript I.

These pointers enable the spatial sequence in each lane to be established and processed without search. Obviously these pointers are revised when one vehicle passes another same lane vehicle. Pointers are also revised when a vehicle in an added passing or climbing lane section changes lanes.

The starting point for processing a particular direction of travel involves two lanes, the normal or left lane (generic lane 1) and a potentially added right lane (generic lane 2). In Direction No. 1, two dummy vehicles are placed 400 ft beyond the end of the simulation road. Subscript 1 is assigned to the dummy in the left lane and subscript 3 is assigned for the dummy in the right lane. The first vehicle to be processed will be the furthest downstream real simulation vehicle, which will be either LG(1), the follower of the dummy in the left lane, or LG(3), the follower of the dummy in the right lane. In a similar fashion, the selection of next to be processed uses candidates which are identified through the LG pointers.

Dummy vehicles with subscripts 5 and 7 are located 50 ft upstream of the entrance end in Direction No. 1. Dummy 5 is in the left lane and Dummy 7 is in the right lane. The dummy vehicles in both lanes are present at all times, even where there is no added passing or climbing lane in a particular direction of travel. The conclusion of Direction No. 1 processing is detected when a dummy vehicle is selected as the next to be processed.

Similar logic is used to initiate and terminate processing in Direction No. 2. Beyond the downstream end of the simulated roadway, Dummy 2 is placed in the left lane and Dummy 4 in the right lane. Beyond the upstream end of the simulated roadway, Dummy 6 occupies the left lane and Dummy 8 occupies the right lane.

Note that the downstream dummies point to themselves as leaders; for example, LD(1)=1, LD(2)=2. Similarly, the upstream dummies point to themselves as followers; LG(5)=5, LG(6)=6. This permits the loading of temporary sequential tables without overflowing or underflowing assigned subscript ranges.

The vehicle subscripts that are not currently in use are accessed through a starting point and the pointer system. NXS is always the subscript of the next available unused set for standard data storage, and LG(NXS) provides the subscript for the next available set. NXS is continually redefined as vehicles enter or leave the simulation.

The pointers for unused standard data storage are initialized in Subroutine PROCI for subscripts 9 through 1,000. The initial sequence is:

9 points to 8, 10 to 9,..., 1,000 to 999, and NXS = 1,000, so that the large subscripts are used first. Thus, the maximum number of vehicles that can be present on the simulated roadway at any one time is 992. If the simulation were to require a 993rd vehicle, the subscript to be used would be 8, which is the subscript for one of the dummy vehicles. The program detects this overflow, writes a diagnostic message and ends the run.

Vehicles passing or aborting a pass require extra data that are assigned only while they are in those states. These extra data, limited to 80 sets by variable dimensions, are arranged in a stack similar to the standard data sets. The next available subscript for extra data is NXE. The pointer to the next available extra data subscript in sequence is IOV(NXE). Pointers are initiated so that 80 is used first and 2 used last.* If a simulation vehicle decides to pass and starts to use NXE=1, the overflow is detected, the simulation is allowed to continue, but the vehicle is not permitted to begin the pass. (A diagnostic message was initially provided for this overflow. It could be reactivated.)

I. The Regional Table

For convenience, some of the data for the vehicle in process is placed in unsubscripted form, and data for same lane leading and following vehicles are placed in unsubscripted or alternative subscripted forms. These data are known as the regional table, because they describe in simple form the current traffic situation in the region surrounding the vehicle in process. The data in the regional table are the primary data used to determine the new position, speed and acceleration for each vehicle in a given review interval. This organization of data was developed and applied in TWOWAF and has been retained in TWOPAS so that the TWOWAF original logic can be employed for vehicles not in added passing or climbing lane sections. However, the data in the regional table have been expanded to facilitate processing in added lane sections.

Basically, the new data organization has double subscripted arrays with one of the subscripts designating generic lane (1 for the normal or left lane, and 2 for the right lane) and the other subscript identifying the type of data stored. These arrays contain the special data for both lanes. When a vehicle is selected for processing, its data are loaded from the double subscripted arrays into the single lane data arrays. Table 5 shows the arrangement of COMMONs and EQUIVALENCEs that form the regional table.

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* Subscript 1 is reserved for temporary use by vehicles that investigate the extension of a pass in progress. (Extension means continuing in the opposing-direction lane to pass the next same-direction impeder.) Consequently, only subscripts 2 through 80 are assignable.

TABLE 5

VARIABLES INCLUDED IN REGIONAL TABLE

Double Subscripted Form	Single Subscripted Form	Corresponding Variable	Description
COMMON/CARA/	Equivalenced to COMMON/CAR/	COMMON/CAR/	
ICARA(1,LN)	ICAR(1)	IP	Standard data subscript (vehicle index) for vehicle in process
ICARA(2,LN)	ICAR(2)	KSIP	State of vehicle in process at beginning of review
ICARA(3,LN)	ICAR(3)	KUT	Vehicle type of vehicle in process
ICARA(4,LN)	ICAR(4)	IDEX	Extra data subscript (if any) for vehicle in process
ICARA(5,LN)	ICAR(5)	NRR1	Standard data subscript (vehicle index) for first following vehicle
ICARA(6,LN)	ICAR(6)	NRR2	Standard data subscript (vehicle index) for second following vehicle
ICARA(7,LN)	ICAR(7)	NRS1	State of first follower
ICARA(8,LN)	ICAR(8)	NRS2	State of second follower
ICARA(9,LN)	ICAR(9)	NROX1	Extra data subscript (if any) of first follower
ICARA(10,LN)	ICAR(10)	NRDX2	Extra data subscript (if any) of second follower
ICARA(11,LN)	ICAR(11)	KSN	State of vehicle in process at end of review
ICARA(12,LN)	ICAR(12)	NAGE	Stage of vehicle in process at end of review
ICARA(13,LN)	ICAR(13)	KT	Largest code for truck
ICARA(14,LN)	ICAR(14)	IOL	Standard data subscript of last found oncoming vehicle
ICARA(15,LN)	ICAR(15)	IAGE	Stage of vehicle in process at beginning of review
ICARA(16,LN)	ICAR(16)	IDR	Standard data index of leader (potential impeder)

TABLE 5 (Continued)

Double Subscripted Form	Single Subscripted Form	Corresponding Variable	Description
COMMON/CARA/	Equivalenced to COMMON/CAR/	COMMON/CAR/	
RCARA(1,LN)	RCAR(1)	XIP	Position (in directional coordinates) of vehicle in process at beginning
RCARA(2,LN)	RCAR(2)	VIP	Speed of vehicle in process at beginning of review
RCARA(3,LN)	RCAR(3)	VDNR	Desired speed of vehicle in process
RCARA(4,LN)	RCAR(4)	COMPL	Leader length plus 15 ft if vehicle in process is in State 5
RCARA(5,LN)	RCAR(5)	XN	Position (in directional coordinates) of vehicle in process at end of review
RCARA(6,LN)	RCAR(6)	VN	Speed of vehicle in process at end of review
RCARA(7,LN)	RCAR(7)	GRD	Local grade (in percent) at beginning of review
RCARA(8,LN)	RCAR(8)	GAIN	Relative advance (ft) to clear impeder in passing maneuver

TABLE 5 (Concluded)

Double Subscripted Form	Single Subscripted Form	Corresponding Variable	Description
COMMON/REGA/	Equivalenced to COMMON/REG/	COMMON/REG/	
IREGA(LN),I=1,3	IREG(J),J=1,3	JST(K),K=1,3	State of Kth leader
IREGA(I,LN),I=4,6	IREG(J),J=4,6	JSTAG(K),K=1,3	Stage of Kth leader
IREGA(I,LN),I=7,9	IREG(J),J=7,9	JUL(K),K=1,3	Standard data subscript (vehicle index) of vehicle being passed by Kth leader or leader to be for vehicle aborting a pass
IREGA(I,LN),I=10,12	IREG(J),J=10,12	JVT(K),K=1,3	Vehicle type of Kth leader
RREGA(I,LN),I=1,3	RREG(J),J=1,3	TMG(K),K=1,3	Time margin (sec) for pass by Kth leader
RREGA(I,LN),I=4,6	RREG(J),J=4,6	VJ(K),K=1,3	Speed of Kth leader
RREGA(I,LN),I=7,9	RREG(J),J=7,9	XJ(K),K=1,3	Position (in directional coordinates) of Kth leader

J. Priming and Reference Speeds

Simulation vehicles are placed, or "primed," on the simulated roadway before the simulation processing begins. The priming logic is deterministic, is performed first for Direction No. 1, then for Direction No. 2. The priming logic deals sequentially with one vehicle type at a time. A vehicle of the type being processed is placed on the road each time that the summation FLOV increases by 1, where FLOV is given by:

$$FLOV = FLOC * [\Sigma(XN\text{-}XIP)/VAV]$$

where:

FLOC = Specified, directional flow rate for the vehicle type, (veh/sec)

(XN-XIP) = Incremental advance (ft) of vehicle traveling by itself along specified highway

VAV = Average speed (ft/sec) during advance (XN-XIP)

Calculations of vehicle advance use the mean desired speed, consider all highway geometrics influencing speed, consider driver preferences on acceleration, and consider the vehicle performance constraints. FLOV is initiated as 0.5 at the entrance to the simulated road.

Low-performance vehicles, whose speed will be determined mostly by performance limits, are primed at approximately the correct densities. Vehicle types whose speeds will be depressed by traffic interactions are primed at a lower density than will be found in the specified flow.

All primed vehicles are placed in the normal or left lane, generic lane 1. This may create an unrealistic situation where generic lane 1, the left lane, is dropped at the end of a passing or climbing lane. It is assumed that the available program logic will resolve the situation during the warmup period before the collection of simulation data begins.

The travel speeds and times of isolated vehicles on the specified road are also calculated with six other desired speeds. These six desired speeds, properly weighted, together with the mean desired speed, approximate the distribution of desired speeds so that the weighted results approximate the overall travel speed and travel time for each vehicle type in the absence of traffic delays. In addition to these "zero traffic" reference values, the speeds on ideal (straight and level) alignment are obtained as additional reference values.

K. Driver Work Load Logic

Driver work load logic was originally incorporated in TWOWAF to influence the desired speeds of simulation vehicles. In the KLD version of TWOWAF, this logic was removed or disabled. It has not been incorporated in TWOPAS.

L. Packed Data

Most data in the program are carried in conventional FORTRAN arrays with one data value in each element. There are five exceptions, DVNOR(1000), KS(1000), FARRAY(128), TVIN(1000), and XHEAD(5000). The elements of these arrays contain packed data.

DVNOR(I) is the normal desired speed (ft/sec) of the Ith vehicle. When the vehicle crosses the start line, the decimal part of DVNOR(I) is replaced with the simulation time (sec) at which the start line was crossed, divided by 10,000. Vehicles primed onto the road prior to starting the simulation have the fractional part of DVNOR(I) equal to zero. Such vehicles are, therefore, recognized in this way and are not processed at the finish lines for determining overall travel data.

KS(I) is the symbol name for data on the state of the Ith vehicle. The possible values of the state are 1, 2, 3, 4, 5, or 6. However, in two cases, the actual state, 1 through 6, is packed into the thousands place of the integer KS(I). For vehicles that are passing (state 5) or aborting a pass (state 6) on a conventional two-lane highway section, the KS(I) is packed as STATE*1000+IDEX, where IDEX is the subscript (1 through 80) for the extra data required in states 5 and 6.

For vehicles in an added passing or climbing lane section, only the states 1 through 4 are meaningful, and for these vehicles, KS(I) is always packed in the following form:

KS(I) = STATE*1000 + LOCC*100 + LTAR*10 + MOT

where: STATE is limited to 1-4

LOCC = Generic lane occupied (1 = left, 2 = right)

LTAR = Target lane, 1 or 2

MOT = Motivation for lane change <u>if</u> LTAR ≠ LOCC; 1 for change lanes to vacate the terminating lane, 2-5 for move left to avoid delay, and 6-9 for move right

XHEAD(M) is the array of vehicles entering the simulation roadway during simulation. Each word contains: time headway, driver type, and vehicle type packed in the following form:

XHEAD(M) = (IH+5)/10*2048 + KDT*64 + KVT

where: IH = Time headway (sec x 10)

KDT = Driver type (range 1-10)

KVT = Vehicle type (range 1-13)

The XHEAD(M) array for entering traffic in Direction No. 1 includes values of M from 1 through XHD(1). The entering traffic in Direction No. 2 includes values of M from XHD(1)+1 through XHD(1)+XHD(2).

FARRAY is a buffer of data assembled for use in determining fuel consumption. Each element of this integer array contains the packed data for one vehicle review interval. Packing into an integer variable FUELDT is performed prior to transfer into the subscripted array. The signed, 14-digit integer FUELDT is:

$$\text{FUELDT} = \pm \text{TTSSVVVVAAAAGG}$$

where: TT = Vehicle type, TT $\leqq$ 13

SS = Road segment, SS $\leqq$ 99 (for TWOPAS, this is always the direction of travel, 01 or 02)

VVVV = Vehicle speed in tenths of a ft/sec. Speed $\leqq$ 999.9 ft/sec

a = Acceleration, range $-25 \leqq a < +25$ ft/sec^2 to nearest 0.005 ft/sec^2

AAAA = 5,000 + 200 * a

GG = Absolute value of local grade in tenths of a percent, where GG $\leqq$ 9.9%

The word carries the sign of the local grade, with a + sign representing an upgrade in the direction of travel of the vehicle in process, and a - sign representing a downgrade.

M. Fuel Consumption Data

Unless disabled by input, data for subsequent fuel consumption calculations are collected for each veh-sec in which the vehicle is in the test section and the time interval is within the test time. The data collected for fuel consumption calculations are:

Vehicle type (1 through 13)
Direction of travel
Vehicle speed at end of review (ft/sec)
Vehicle acceleration used during review interval (ft/sec^2)
Local grade (%)

The data are packed in a single array element (see above discussion of packed data) and, when 128 array elements have been filled, the entire array is written as a single record on Unit 10.

Prior to simulation processing, three or more records are written on Unit 10 with information describing the run. At the conclusion of simulation processing, the remaining portion of the 128-element array is filled with zeros, and the last array is then written on Unit 10.

N. Random Numbers and Their Use in Related Runs

Five independent sequences of random numbers are generated using the Function RAN(N),N =1,5. Random number generation details are described in the discussion of Function RAN(N) in Appendix A. However, it should be noted that each sequence of random numbers is started from a seed that can be supplied in input. The applications of the random number sequences have been chosen so that the selection of a random number seed can be used advantageously in pairs of simulation runs to be compared.

The random number applications are listed below with attention to the sequences of uses.

The first random number seed (N=1) is used to generate Direction No. 1 platoons, headways, vehicle types, and driver types in entering traffic stream, which is assembled prior to the simulation run for use during simulation processing.

The second random number seed (N=2) is analogus to the first random number seed for Direction No. 2 platoons, headways, vehicle types, and driver types in the entering traffic stream.

The third random number seed (N=3) is used to select desired speeds for vehicles entering the simulated roadway in Direction No. 1.

The fourth random number seed (N=4) is used to select desired speeds for primed vehicles prior to the beginning of simulation processing. During simulation processing, this random number sequence is used (without reset) for stochastic decisions on pass acceptances and pass extensions, tests on motivations to change lanes, and lane choice at lane additions of passing or climbing lanes.

The fifth random number seed (N=5) is analogus to the third random number seed and is used to select desired speeeds for vehicles entering the simulated roadway in Direction No. 2.

These applications enable the user to specify two or more simulation runs with closely parallel sample characteristics. For example, the goal may be to evaluate the benefits accruing from a geometric improvement that reduces a grade or decreases the percent no-passing. If the two geometrics are run with the same specified traffic flows and with exactly the same random number seeds, the traffic samples in the two runs will be closely related. In each run, exactly the same sequence of vehicle types will enter in each direction, the entering headways will be repeated, and the desired speeds will be the same sequences assigned to the same vehicle types. Comparisons such as this reduce the variance associated with traffic samples and consequently offer the possibility of detecting differences with a minimum of simulated time. However, the statistical experiment must be considered carefully and, if general statements are to be made, replicate runs under both geometric conditions will normally be required.

O. Temporary Flags

Temporary flags are set in two cases during simulation processing:

1. When a vehicle in a single lane section passes a same-direction vehicle, the passed vehicle's speed V(N) is flagged with a negative sign. If the passed vehicle was the "oncomer" to an opposing-direction pass, the flag indicates that the next vehicle forward is now the appropriate oncomer. The negative sign is removed when the vehicle is processed in the next review.

2. When a vehicle changes lanes in an added passing or climbing lane section, the lane changer's desired speed VDNOR(IP) may be flagged with a negative sign. The flag is added if the changer entered the target lane behind an unprocessed vehicle there. The flag is used to prevent double processing; it is removed when the vehicle again comes up for processing and is bypassed.

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APPENDIX A

DESCRIPTION OF SUBROUTINES AND FUNCTIONS

APPENDIX A

DESCRIPTION OF SUBROUTINES AND FUNCTIONS

1. Main Program (TWOPAS)

a. Purpose: This is the single main program for the TWOPAS simulation model.

b. Approach: The approach is illustrated in Figure 1 in Section II of this volume.

c. Synopsis: See purpose.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: ADV2, ALN, AMC, CLEN2, CXSTA, ENTR, EPLAT, ERASE2, FPUT2, GENTB, OPUT, PASZ2, PRIM2, PROCI, REED2, SAVERF, SETFF, SETZK, SNAP2, ST14, ST5, ST6, TINC2, VGEN, XBUGO, RAN.

Called by: None.

f. Formal parameters: None.

g. Common blocks: Blank, AKPM, BKPM, CAR, EP, FHP, FUL, GEN, LNCH, PAS, PCTOUT, PLAT, PS, REUB3, ROA, SPE, STAT, SWT, TIM, VEH, XCOUNT.

h. Local variables:

Name	Description
ALL	Dimensioned array, no longer used.
I	Index of loop.
IDUM	Utility variable.
IEMTF	Code used to indicate whether or not a vehicle has been entered onto the simulated roadway by Subroutine ENTR. The value 1 indicates that a vehicle has been entered, while the value 0 indicates that a vehicle has not been entered.
IRN	Random number.

Name	Description
ITEND	Code indicating whether or not the simulation time period is complete. The value 0 indicates that the simulation time period is not complete. The value 1 indicates that the simulation time period is complete.
ITO	Subscript of times (min) at which extra output has been specified by the user [TO(ITO)].
I1	Argument for RAN().
K	Index of loop.
KD	Subscript for direction of travel, 1 or 2.
KNLP	Subscript for direction of travel, 1 or 2.
KNLP	Code supplied to Subroutine ADV2. When KNLP is equal to 1 or 2, it represents the lane occupied by the vehicle just processed; when KNLP equals 3, this indicates that the program is starting to process a new direction.
KNX	Code returned by Subroutine ADV2.
MS	Maximum user-specified station in direction treated.
NLAA	Code returned by Subroutine ADV2. The value of NLAA represents number of lanes available to next vehicle to be processed in its direction of travel, 1 or 2.
RN	Random number generated by RAN() function.

i. Modifications from TWOWAF: The main program has been entirely revised for TWOWAF.

j. Error messages: None.

2. Subroutine ADJ1

a. Purpose: Adjust subscripts for highway characteristics in Direction No. 1 in preparation for evaluating characteristics of specified highway at a specified position X1. This routine is part of processing to print highway characteristics prior to exercising simulation logic.

b. Approach: Tests X1 against upstream end of region. Revises to lower subscript region if necessary for upstream end less than or equal to X1. If upstream end coincides with X1 sets IOV(KSS) equal to next lower subscript if legitimate.

Returns KS(KSS) as most downstream subscript for region containing X1 and IOV(KSS) as most upstream region that includes X1.

c. Synopsis: See purpose.

d. Assumptions: Uses simulation processing variables in nonstandard applications as described in the approach section.

e. Relationship to other subroutines:

Calls: None.

Called by: OPUT.

f. Formal parameters:

Name	Description
KSS	Variable number to be processed.
NJ	Minimum region subscript for variable in No. 1 Direction.
XMIN	Symbol name for upstream end of variable region.

g. Common blocks: ADJ, EXT, VEH.

h. Local variables:

Name	Description
IDUM	Used to index XMIN array.

i. Modifications from TWOAF: None.

j. Error messages: None.

3. Subroutine ADJ2

a. Purpose: Adjusts subscripts for highway characteristics in No. 2 Direction in preparation for evaluating characteristics of specified highway at position X2. This is part of processing to print highway characteristics prior to exercising simulation logic.

b. Approach: Tests X2 against upstream end of region. Revises to higher subscript region of necessary for upstream end greater than or equal to X2. If upstream end coincides with X2, sets IOV(KSS) equal to that region's subscript.

Returns with KS(KSS) as most upstream subscript region (in No. 2 Direction coordinates) that contains X2 and IOV(KSS) as most downstream region that includes X2.

c. Synopsis: See purpose.

d. Assumptions: Uses simulation processing variables in nonstandard application as described in approach.

e. Relationship to other subroutines:

Calls: None.

Called by: OPUT.

f. Formal parameters:

Name	Description
KSS	Variable number to be processed.
MJ	Maximum region subscript for variable in No. 2 Direction.
XMIN	Symbol name for upstream end of variable region.

g. Common blocks: ADJ, EXT, VEH.

h. Local variables:

Name	Description
IDUM	Used to index XMIN array.

i. Modifications from TWOWAF: None.

j. Error messages: None.

4. Subroutine ADV2(NLP,KNX,NLAA)

a. Purpose: Advances the double subscripted form of the regional tables for both one or two lane sections; determines which vehicle or lane is to be processed next; transfers the double subscripted data for the selected lane into single subscript arrays; updates the coefficients for curve, crawl, and grade regions; and initializes codes KAI, ITRY, IGO, and COMPL.

b. Approach: After initializing codes, the double subscript forms for the regional table are advanced so that the index of the foremost unprocessed vehicles are in ICARA(1,K),K=1 and 2. During this processing, the foremost vehicle is tested for a state greater than 5000 which indicates a vehicle in a section with one lane and in the process of a normal pass or pass abort. These packed states are unpacked to single digit states of 5 or 6. The packed states 1000 through 4999, signifying a vehicle in a section with two lanes, are left packed. (Note also that conventional symbol names IP, NRR2, and NRS2 are used temporarily in processing.) For a lane advanced in the table, a test is made to determine if the vehicle has been processed previously and changed lanes in the current review. If so, the table for the affected lane is advanced again to obtain an unprocessed vehicle.

The first unprocessed vehicle in each of the directional lanes is tested for most advanced position. That lane and vehicle is selected for processing next. In a tie, the left lane (generic lane 1) is selected. (Recognize that if the section only has one lane, the test will see a real vehicle or a dummy further upstream in the lane not present locally.) The regional data for the selected lane is placed in single subscript form.

The state of the vehicle to be processed is tested; if less than 1000, it is in single lane section and NLAA is equal to 1; if greater than 1000, it is in added lane section, NLAA is equal to 2 and UNPAC is called to unpack the state.

The curve, crawl, and grade coefficients are updated if necessary.

c. Synopsis: Selects next vehicle to be processed and prepares tables, coefficients, and codes.

d. Assumptions: When both lanes are advanced (NLP = 3), the routine assumes that it will not find a vehicle which has changed lanes during review in process. (NLP = 3 only when initiating tables to begin processing in a direction.) The same assumption is made after correcting for a previously processed lane changer when K is set to NLP.

e. Relationship to other subroutines:

Calls: UNPC.

Called by: Main program (TWOPAS).

f. Formal parameters:

Name	Description
KNX	Number of generic lane occupied by vehicle to be processed next (1 = left lane (or only lane), 2 = right lane). Returned.
NLAA	Number of lanes available at position of vehicle to be processed. Returned.
NLP	Code for lanes to be processed in table advanced by this routine; 1 for generic lane 1, 2 for generic lane 2, and 3 for both 1 and 2.

g. Common blocks: CAR, CARA, CV, CW, DSV, EP, GD, GEO, LNCH, REG, REGA, ROA, VEH.

h. Local variables:

Name	Description
IDUM	Subscript of vehicle found to be previously processed.
K	Generic lane number for which table is advanced.
KOUT	Single digit state of vehicle in section with passing lane.

i. Modifications from TWOWAF: In TWOWAF, Subroutine ADV performed the table advance for one unidirectional lane and updated the coefficients for curve, crawl, and grade. In Subroutine ADV2, the first part of the routine handles two lane sections, their regional table data and the selection of next vehicle and lane to process. The original logic of Subroutine ADV is used in numbered statement 10, and those that follow, to process one-lane sections.

j. Error messages: None.

5. Subroutine ALN(KNX)

a. Purpose: Called for vehicles with a packed state indicating they are in an added passing or climbing lane section. Calls appropriate routine for type of added lane section.

b. Approach: Calls PASZ2(XIP) to obtain JPAS, the code for type of passing zone or added lane section. Branches on JPAS.

c. Synopsis: Calls appropriate routine for type of added lane section occupied by vehicle in process.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: AL21, PASZ2; note calls to unimplemented routines SHODR (for shoulder use sections) and TRNOT (for turnouts) are commented out.

Called by: Main program (TWOPAS).

f. Formal parameters:

Name	Description
KNX	Not used.

g. Common blocks: CAR, IDRT, LNCH, PAS, TIM, VEH.

h. Local variables: None.

i. Modifications from TWOWAF: None, new routine in TWOPAS. Will require modification to implement sections with shoulder use or turnouts.

j. Error messages:

Message: ERROR: VEHICLE WITH ADDED LANE STATE [KS(IP)] FOUND AT XIP [XIP] TIME=[TIME] JPAS=[JPAS].

Meaning: Vehicle in process has state indicating presence in added lane section but there is no added lane at position XIP.

Message: ERROR, SHOULDER USE AND TURNOUT SECTIONS NOT IMPLEMENTED.

Meaning: JPAS for position XIP has been found to be greater than 3.

6. Subroutine AL21

a. Purpose: Handles processing of vehicles found to be in an added lane section.

b. Approach: Initializes codes; obtains acceleration constraints in call to SPDN(2); determines if driver is motivated to change lanes or should be motivated to change lanes; if motivated, attempts lane change. If a lane change to avoid delay or avoid lane drop fails, Subroutine FAILG is called; if FAILG finds gap for a future lane change, the vehicle is advanced to pursue that gap. If no future gap is found or if the vehicle is not motivated for lane change, it is advanced by a call to SPDN(3).

c. Synopsis: Processes vehicles in added lane section.

d. Assumptions: Will be called only for vehicles in added lane sections with JPAS = 2 or 3, and after the initial state, KSIP, has been unpacked to the single digit form.

e. Relations to other subroutines:

Calls: CHLMO, CHRMO, CLPRM, DRPAV, DRPMO, EGAP, FAILG, SPDN.

Called by: ALN.

f. Formal parameters: None.

g. Common blocks: AAMN, PAS, LNCH, VC, VIC, REG.

h. Local variables:

Name	Description
AMN	Maximum acceleration vehicle can use during current review while attempting lane change.
AMN	Minimum acceleration vehicle can use during current review while attempting to change lanes.
IDUM	Vehicle type of immediate leader in current lane.
IGOX	Temporarily equal to IGO; returned in COMMON from FAILG.
IM	Code used as formal parameter in called routines (1) for lane change motivation established this review: = 0, was not motivated; > 0, was motivated; IM ≧ 26 for greater urgency; and (2) for test to determine if lane change was precluded: = 0, not precluded; > 0, precluded.

i. Modifications from TWOWAF: None, new routine.

j. Error messages: None.

7. Subroutine AMC

a. Purpose: To calculate the features of a pass abort maneuver when it is initiated, i.e., at first entry into state 6.

Note: This is the only maneuver which is not reviewed for changes during ensuing simulation time.

b. Approach: AMC calculates the time before the aborting vehicle can start to vacate the opposing lane, the position relative to the impeder where the lane change will begin, and the speed of the aborting vehicle when the lane change will begin. The calculations employ the initial positions and speeds of the aborting vehicle and the impeder which was being passed. Large decelerations are projected for the maneuver if required to establish a negative speed relative to the impeder. The vehicle is then processed by subroutine ST6 for the time interval in process.

Routine AMC returns VPM(IDEX) = Distance behind leader-to-be where aborter will begin return to normal lane.

TMRG(IDEX) = Time (sec) until aborter will clear leader-to-be plus 1 sec.

ISTG(IDEX) = 1 If there is a delay (TMRG 0) before lane change can begin.

= 5 If lane change can begin immediately.

XIP = X(IGI)-1 If leader-to-be is also aborting (i.e., KS(IGI) = 6).

c. Synopsis: Calculates pass abort maneuver.

d. Assumptions: If necessary, aborting vehicle will use deceleration of 18 ft/sec^2 and reduce speed to 10 ft/sec less than leader-to-be in order to clear leader-to-be and return to normal lane.

e. Relationship to other subroutines:

Calls: None.

Called by: Main Program TWOPAS.

f. Formal parameters: None.

g. Common blocks: EXT, STA, VEH.

h. Local variables:

Name	Description
DUM	Initial overlap with vehicle that is leader-to-be.
IDUM	Vehicle type of leader-to-be.
IGI	Vehicle index or subscript of leader-to-be.
U	Initial speed advantage, i.e. (speed of vehicle in process) - (speed of leader-to-be).
DUM1	When there is no initial overlap with leader-to-be, the time to decelerate to speed of leader-to-be. When there is initial overlap, the time to decelerate to speed 10 ft/sec less than leader-to-be. Subsequently, DUM1 is set equal to time until overlap goes to zero.
Y	If there is initial overlap with leader-to-be, Y is overlap at time speed is 10 ft/sec lower than leader-to-be. And if overlap goes to zero during deceleration, Y is calculated as overlap at 1-sec intervals until time before zero overlap is found. If there is no initial overlap with leader-to-be, Y is calculated as projected overlap when speed of aborter and leader-to-be become equal.

i. Modifications from TWOWAF: None.

j. Error messages: None.

8. Subroutine CALQD(DY,DV,JQ)

a. Purpose: Returns JQ as the quadrant for a vector with abscissa component DY and ordinate component DV. Used in computing vehicle trajectories for future lane changes in the sequence of routines called by FAILG.

b. Approach: Test values of DY and DV.

c. Synopsis: Returns as JQ the quadrant for a vector with abscissa component DY and ordinate component DV.

d. Assumptions: Routine will not be called when both DY and DV are zero. In that case, JQ would not be defined. Note:

1st quadrant: > 0°, ≦ 90°
2nd quadrant: > 90°, ≦ 180°
3rd quadrant: > 180°, ≦ 270°
4th quadrant: > 270°, ≦ 0°

e. Relationship to other subroutines:

Calls: None.

Called by: TRAJT.

f. Formal parameters:

Name	Description
DV	Ordinate (or vertical) component of vector. Supplied by calling routine.
DY	Abscissa (or horizontal) component of vector. Supplied by calling routine.
JQ	Quadrant occupied by vector. Returned.

g. Common blocks: None.

h. Local variables: None.

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

9. Subroutine CHLMO(IM)

a. Purpose: This routine is called for vehicle in the right lane of an added passing or climbing lane. It determines if the vehicle should be motivated to change to the left lane in order to avoid delay or avoid a lane drop.

b. Approach: Partially separate logic is used for vehicles with states 1 or 2 (undelayed) and vehicles with states 3 or 4 (already experiencing delay). The probability of motivation to change lanes is assembled from: time until delay, severity of delay, comparative outlook for delay in the left lane, and the likelihood of conflict/blocking by vehicles in the left lane. The numerics employed in this routine are based on experience with a multilane highway simulation model.

c. Synopsis: Calculates probability that vehicle in the right lane of an added passing or climbing lane should be motivated to change to left lane. Makes decision and sets code IM for outcome.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: CONFL, GAP, RAN(4).

Called by: AL21.

f. Formal parameters:

Name	Description
IM	Code returned to calling routine; = Ø if not motivated, > Ø as IFIX(10.*PROB) for motivated with the magnitude proportional to motivation urgency.

g. Common blocks: CAR, CARA, LNCH, QUA, REG, REGA.

h. Local variables:

Name	Description
CADD	Factor for fraction of time before catch up that conflicting vehicles will block lane change. This factor is an addition to the probability that a vehicle will become motivated to change lanes. Value defined as 0.1 in data statement.
CHI	Largest time (measured from catch-up) in region of interest when a conflicting vehicle would block lane change (sec).
CLO	Smallest time (measured from catch-up) in region of interest when a conflicting vehicle would block lane change (sec).
CL1, CL2, CL3	Conflict times returned by Subroutine CONFL (sec).
CT(I)	Subscripted names for CL1, CL2, CL3 (sec).

Name	Description
CTES	Value of CT(I) selected to calculate CLO (sec).
DEL	Time interval which may be added to time that lane change would be blocked by a conflicting vehicle (sec).
DV	Speed difference, vehicle in process minus speed of immediate leader in same lane (ft/sec).
DVL	Speed difference, left lane leader minus right lane leader (ft/sec).
DXL	Distance difference, left lane leader position minus right lane leader position (ft).
I	Index of loop.
J	Index of loop.
PADD	Addition to probability that a vehicle will become motivated to change lanes; based on conflict considerations.
PROB	Probability that vehicle should be motivated to change lanes.
RAND	The random number (0.-1.0) returned by call to RAN(4).
TC	Time to catch up with (actually time until influenced by) immediate leader in same lane (sec).
TCOEF	Factor for contribution to PROB that is inversely proportioned to TC (sec). Value defined as 0.8 in a data statement.
TGAP	Time interval beyond TC when conflicting vehicles are no longer important (sec). Value defined as 5.0 in a data statement.
VADVT	Speed advantage of vehicle in process over immediate leader including effects of acceleration capabilities and speed preference (ft/sec).

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

10. Subroutine CHRMO(IM)

a. Purpose: This routine is called for vehicles in the left lane of an added passing or climbing lane. It determines if the vehicle should be motivated to change to right lane. The routine makes the lane change motivation decision and sets a code accordingly.

b. Approach: A probability of motivation is assembled beginning with a bias based on vehicle category (truck/RV/car). If the vehicle in process is faster than its right lane leader and the right lane leader would become an impeder in 10 sec or less, the probability is set equal to zero so the vehicle will not become motivated to change lanes. Otherwise, the probability of motivation is increased for: long times until delay in right lane, vehicle in process delaying its followers, vehicle in process free and with small acceleration capability, or vehicle in process free and at low speed relative to desired mean speeds. If probability is greater than zero and less than one, the decision to become motivated to change lanes is made stochastically with a random number from RAN(4).

c. Synopsis: Determines if vehicle in left lane should be motivated to change to right lane. Sets code for outcome.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: GAP, RAN(4).

Called by: AL21.

f. Formal parameters:

Name	Description
IM	Code for outcome: = 0 if not motivated, = 5 if motivated. Returned.

g. Common blocks: CAR, CARA, LNCH, QUA, REG, REGA, VEL.

h. Local variables:

Name	Description
BIAS(KVCAT)	Bias in determination of probability of lane change motivation. Value varies by vehicle category. Defined in data statement as 0.1, 0.05, 0.00 for KVCAT = 1, 2, 3 (truck/RV/car).

Name	Description
DV	Speed difference, vehicle in process minus right lane leader (ft/sec).
KVCAT	Vehicle category for vehicle in process; 1, 2, 3 for trucks, RVs, and passenger cars.
PROB	Probability of motivation to change lanes to right lane. An algebraic accumulator.
RAND	The random number returned by RAN(4).
TC	Time to catch up or, more precisely, time before vehicle in lane on the right would become an impeder (sec).

i. Modifications from TWOWAF: None, new routine in TWOPAS. Program logic and numerical values are based on experience with a multilane highway simulation model.

j. Error messages: None.

11. Subroutine CLEN2(NLA,LN)

a. Purpose: Routine is called for a vehicle after it has been processed for the review interval and after the data for the vehicle review has been extracted. The routine begins the updating of pointers and the regional tables. If the vehicle has changed lanes in an added lane section, LCBOK is called for associated bookkeeping. If a vehicle has overrun the end of a dropped lane, DROPV is called.

b. Approach: Interrogates variables and codes for beginning and end of vehicle review. Directs program logic for needed updating and bookkeeping.

c. Synopsis: Performs part of updating and bookkeeping after a vehicle has been processed. The remainder is done in ADV2.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: FRAK, LCBOK, PLNC, DROPV, FVEH, WELD, SERT.

Called by: Main Program TWOPAS.

f. Formal parameters:

Name	Description
NLA	Number of lanes available at vehicle position at beginning of review interval in the direction of travel of the vehicle in process.
LN	Generic lane occupied by vehicle at beginning of review: 1 = left, 2 = right. (Will be 1 when only one lane is available.)

g. Common blocks: CAR, CARA, EP, EXT, FUL, LNCH, PAS, PCTOUT, PS, QUA, REG, REGA, REUB1, ROA, TIM, VEH, VEL.

h. Local variables:

Name	Description
DUNN	Utility variable.
IPM	Standard data subscript for first unprocessed vehicle in generic lane 2, the right lane.
LCON	Generic number of lane continued through drop: 1 = left lane continues, 2 = right lane continues.

i. Modifications from TWOWAF: This routine contains new logic added for TWOPAS and part of the original logic in subroutine CLEAN from TWOWAF. This routine does not contain the tests formerly performed in CLEAN for crossing start/finish lines, etc.; those tests are now made in CXSTA. The new logic tests for vehicles which have moved into or out of an added lane section. When found, new logic is provided for decisions and initial bookkeeping. The logic retained from CLEAN adjusts the regional table data for a lane.

j. Error messages: If a vehicle is found in a dropped lane, the printed message is:

VEHICLE [IP] FOUND IN DROPPED LANE AT [XN], DIRECTION [JD], SPEED [VN], IGO = [IGO], TIME [TIME].

12. Subroutine CLPRM(IM,AMX,AMN)

a. Purpose: Sets code IA for the limiting risk level for use in lane changing and returns AMX and AMN as limits on the maximum and minimum accelerations to be used in the current review interval to accomplish a lane change.

b. Approach: The code and the accelerations are calculated in separate logic for each type of lane change motivation. Logic for lane changes to avoid the lane drop begins at statement 100; logic for lane changes to move left to avoid delay begins at statement 200; and logic for lane changes to move right begins at statement 300. In addition to the motivations, the logic uses acceleration limits from a prior call to SPDN(2) and considers the urgency of the lane change.

c. Synopsis: This routine calculates limiting parameters for use in attempting a lane change during this review interval.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: AL21.

f. Formal parameters:

Name	Description
AMN	Minimum acceleration to be used in attempting to change lanes during this review.
AMX	Maximum acceleration to be used in attempting to change lanes during this review.
IM	Code for urgency of lane change motivation. Larger values are associated with more urgency. (IM may be zero if the vehicle was motivated in prior review interval.)

g. Common blocks: AEOL, CAR, LNCH, PAS, PS, QUA, RE.

h. Local variables:

Name	Description
DTOD	Distance to lane drop at beginning of review (ft).
DUM	Potential reduction from AMX to AMN.
F	A calculated factor proportional to urgency for lane change; F ranges from 0. to 1. for avoiding delay, and from 0. to 5. for avoiding lane drop.
TTOD	Projected time to reach lane drop at constant speed (sec).

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

13. Subroutine CONFD(NOLN,LNA)

a. Purpose: Assembles data on nearby vehicles in currently occupied lane and data on nearby vehicles in potential target lane for use in evaluating lane changes by vehicles approaching the lane drop of a passing or climbing lane. Data are used in DRPMO to evaluate potential conflicts that may block access to the target lane.

b. Approach: Data in the regional table are used to assemble the relative positions and the speeds of nearby vehicles in the occupied and target lanes. The results are returned in common COND.

c. Synopsis: Assembles data on potentially conflicting vehicles in the occupied and potential target lane of a vehicle that may be motivated to vacate the terminating lane.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: DRPMO.

f. Formal parameters:

Name	Description
LNA	Generic number of potential target lane: 1 = left, 2 = right. Supplied by calling routine.
NOLN	Code for lanes to be processed: 1 = data for lane occupied, 2 = data for target lane, 3 = data for both lanes. (This option is not currently used; NOLN = 3 in the only call in TWOPAS.)

g. Common blocks: CAR, CARA, COND, REG, REGA, TIM, VEH.

h. Local variables:

Name	Description
I	Do loop index and utility integer.
J	Utility integer.
K	Utility integer.

i. Modifications from TWOWAF: None, new subroutine in TWOPAS.

j. Error messages: None.

14. Subroutine CONFL(CL1,CL2,CL3)

a. Purpose: CONFL is called for vehicles in the right lane in an added passing or climbing lane section that may be motivated to change lanes to the left to avoid delay. The routine calculates the times of potential conflicts when left lane vehicles would block a lane change.

b. Approach: Logic uses regional table data to treat in order: (1) the first unprocessed vehicle in target lane, (2) the first follower of that vehicle, and then (3) the second follower of that vehicle. In each case, the speed difference with vehicle in process is calculated. If target lane vehicle would not overtake vehicle in process, time to overtake is set equal to 1,000 sec. Otherwise, time to overtake vehicle in process is calculated and returned in formal parameter.

c. Synopsis: Calculates times to potential conflicts with followers in target lane.

d. Assumptions: Neglects conflicts that could arise from overtakers in lane occupied.

e. Relationship to other subroutines:

Calls: None.

Called by: CHLMO.

f. Formal parameters:

Name	Description
CL1	Time until first unprocessed vehicle in left lane would draw even with vehicle in process (sec). Returned.
CL2	Same time calculated for follower of first unprocessed vehicle in left lane (sec). Returned.

Name	Description
CL3	Same time calculated for second follower of first unprocessed vehicle in left lane (sec). Returned.

g. Common blocks: CAR, CARA, REG, REGA, TIM, VEH.

h. Local variables:

Name	Description
DV	Speed difference, target lane vehicle minus speed of vehicle in process (ft/sec).
NR	Subscript for target lane vehicle.

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

15. Subroutine CRFW2(RXLN,RXF,RL,RVLN,RVF,RB,RT,RC,RAL,RAF, RAK, RXFN,RVFN)

a. Purpose: Calculates an acceleration for the vehicle in process based on the immediate leader. This routine incorporates the car-following model.

b. Approach: Extrapolates the leader's position backward in time to beginning of review using the leader's new speed and position. Obtains the car following coefficient for the vehicle in process based on that vehicle's driver type. Tests follower-leader interaction conditions to branch to appropriate equations for follower acceleration based on one of seven possible car-following cases considered here (Cases 1 through 7). Calculates an acceleration based on interaction with leader, and, if acceleration increases, applies potential constraint based on limiting jerk ($ft/sec^2/sec$).

c. Synopsis: Calculates an acceleration based on interaction with the leader.

d. Assumptions: Assumes the leader has been processed for the time interval treated.

e. Relationship to other subroutines:

Calls: TRACE.

Called by: SPDN.

f. Formal parameters:

Name	Description
RXLN	Position of leader at conclusion of interval. Supplied by calling routine.
RXF	Position of follower at beginning of interval. Supplied by calling routine.
RL	Lead vehicle length. Supplied by calling routine. (Set equal to zero in current application with RXLN being supplied as position of rear of leader.)
RVLN	Speed of leader at conclusion of interval. Supplied by calling routine.
RVF	Speed of follower at beginning of interval. Supplied by calling routine.
RB	Car following constant with units sec/ft. Supplied by calling routine. This coefficient is used with speed squared term and is independent of driver type.
RT	Simulation time step (sec). Supplied by calling routine.
RC	Driver reaction time (sec). Supplied by calling routine.
RAL	Leader acceleration at conclusion of time interval (ft/sec**2). Supplied by calling routine. Not used in this logic, but retained for compatibility with previous versions.
RAF	Follower acceleration (ft/sec**2). Previous value supplied by calling routine. New value returned to the calling routine.
RAK	Follower stochastic car-following factor. Supplied by calling routine. (Dependent on driver type.)
RXFN	Follower position at conclusion of time interval. Returned to calling routine.
RVFN	Follower speed at conclusion of time interval, to calling routine.

g. Common blocks: RAMAX, RVMAX, ZK, ZVC, YTRACE. (Note: ZVC is not employed in current logic.)

h. Local variables:

Name	Description
AED	Typical positive acceleration, defined as 5.0 in data statement.
CA	Coefficient of DADYO in Case 5.
COEF1	Coefficient of (FAZ+FAC) in Cases 1 and 2.
COEF2	Coefficient of DADYO in Cases 1 and 2.
DADY	Rate of change of acceleration for position evaluated with acceleration equal to AED.
DADYO	Rate of change of acceleration for position evaluated where acceleration equal to zero.
DENOM	The denominator of expression for DADY.
DUM	A coefficient in Case 5.
ETA	A coefficient equal to the maximum fraction of the (YC-YDZ) distance that can be penetrated in one review by a nondecelerating follower (for Cases 1 through 3). Defined in data statement as 0.3.
FAZ	The acceleration required to remain at overtaking conditions where zero acceleration would have been called for in the revised KLD-Pitt model.
FAC	The acceleration (always negative) required to remain at critical overtaking conditions.
IK	Integer form of leader speed. Limited to range 1 to 100. Used as subscript for ZK.
ITYP	Case type for car-following evaluation: = 1 for RVF > RVLN, YC > YDZ, and YX ≦ YDO≦YC = 2 for RVF > RVLN, YC > YDZ, and YDO > YC = 3 for RVF > RVLN, YC > YDZ, and YDO < YX = 4 for RVF > RVLN, YC ≦ YDZ, and YDO ≧ YC = 5 for RVF > RVLN, YC ≦ YDZ, and YDO < YC = 6 for RVF ≦ RVLN and YDO ≧ 0 = 7 for RVF ≦ RVLN and YDO < 0

Name	Description
RA1	Initially calculated new acceleration for follower.
RA2	New acceleration constrained by deceleration capability and by requirement for final speed $\geqq 0$.
RA3	New acceleration RA2 constrained by limit on jerk for positive accelerations.
REE	Emergency, or maximum, deceleration expressed as a positive number. Defined in data statement as 15.
RJERK	Limiting jerk, i.e., maximum positive rate of change of acceleration (ft/sec^3). Defined in data statement as 5.
RKU	Steady following time gap (sec) based on characteristics of following driver and leader speed.
RKV	Steady following time gap (sec) based on characteristics of follower driver and follower speed.
RTAU	(Simulation time step) - (Driver reaction time) = RT-RC (sec).
VMN	A speed at and below which the steady following time gaps for all driver types become 2.0 sec. Defined in data statement as 5.0 ft/sec.
YC	A relative position where the follower (with existing leader and follower speeds) would be at the condition defined by the emergency stopping constraint. The relative position YC is measured in the direction of travel from the steady following position for speed equal to leader speed (ft).
YDO	The relative position of the follower at the beginning of the review interval. YDO is measured in the direction of travel from the steady following position for speed equal to leader speed (ft).
YDZ	The relative position of the follower where acceleration would be zero in the improved KLD-Pitt model. YDZ is measured in the direction of travel from the steady following position for speed equal to leader speed (ft).

Name	Description
YX	The relative position of the follower where acceleration would be zero in the current model for Cases 1, 2, and 3. YX is measured in the direction of travel from the steady following position for speed equal to leader speed (ft).

i. Modifications from TWOWAF: The logic in this routine is new. However, it was developed to mimic some features and revise other features of the old subroutine CRFWL which contained the Pitt model with improvements by KLD. The features or car-following responses retained are: the driver steady following characteristics including capacity operation, the variations between 10 driver types, the general dynamic interaction response of each driver type in overtaking slower vehicles, and the treatment of driver response delay. The list of formal variables in the call statement has been retained to agree with the routine CRFLW written by KLD.

By shifting the conceptual time scale, the new acceleration calculated here for a follower can be applied over the entire review interval while retaining the effect of driver response delay.

The KLD-Pitt model provided strong changes in acceleration so as to force an overtaking vehicle to oscillate markedly around an approach path containing the zero acceleration conditions. Only the use of jerk constraints in the old subroutine CRFWL prevented very large excursions into negative and positive accelerations. CRFW2 provides much more moderate responses to deviations from the zero acceleration conditions, and jerk constraints are used only for positive accelerations. Consequently, the dynamic vehicle interaction conditions leading to follower decelerations can be used in other logic to define acceptable risk conditions for lane changing.

j. Error messages: None.

16. Subroutine CROSS(XO,VO,SLO,X1,V1,X2,V2,XCC,VCC,ISOL)

a. Purpose: Finds the intersection of two straight lines; finds relative value of their slopes; provides for case of parallel lines.

b. Approach: One line representing the leader constraint is defined in slope-intercept form; the other line, representing a segment of the risk acceptable boundary, is defined by two points. Guards are provided against very small denominators in the solution for the slope of two-point line and the solution for intersection of the two lines.

c. Synopsis: Calculates intersection of two straight lines and the relative magnitudes of their slopes. Provides for parallel lines.

d. Assumptions: If the line representing the leader constraint is nearly vertical, it is assigned a slope of -2000 in accord with logic about the character of leader constraint.

e. Relationship to other subroutines:

Calls: None.

Called by: GTRIM.

f. Formal parameters:

Name	Description
XO, VO, SLO	The horizontal position coordinate, the vertical coordinate (a speed), and slope of the line representing the leader constraint. Supplied by calling routine.
X1, V1, X2, V2	The horizontal position coordinates (X1 and X2) and vertical coordinates (V1 and V2) for points defining a segment of the risk-acceptable boundary. Supplied by calling routine.
XCC, VCC	The horizontal position coordinate and vertical (speed) coordinate of the intersection point. Returned to calling routine.
ISOL	Code returned to calling routine; equal to zero if lines are parallel; < 0 if leader constraint slope is less than slope of risk boundary segment; > 0 if leader constraint slope is greater than slope of risk boundary segment.

g. Common blocks: None.

h. Local variables:

Name	Description
SL2	Slope of risk-acceptable boundary calculated as (V2-V1)/(X2-X1).

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

17. Subroutine CXSTA

a. Purpose: This routine is called when a vehicle has been processed but before the regional table is updated. The routine determines what data from the vehicle review should be stored and calls the subroutines required.

b. Approach: This routine determines the directional subscripts for user-specified data collection stations including the station upstream or equal to the vehicle's initial position and the station upstream or equal to vehicle's final position. Subsequent tests indicate whether a station has been crossed during the review interval, and what data are to be stored. The required subroutines for data storage are then called.

c. Synopsis: Following a vehicle review, determines what data should be stored and calls required subroutines.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: DBSPT, DROPV, DSTA, FLIN2, FRAK, FSTA, SLIN2, SSTA, STOR2.

Called by: Main Program (TWOPAS).

f. Formal parameters: None.

g. Common blocks: CAR, KTES, LNCH, NX, ROA, STAT, TIM.

h. Local variables:

Name	Description
FRAC	Fraction of review interval that vehicle in process spent traveling from initial position XIP to a station or boundary at XDUM.
I	Index of loop.
IDAT(I)	Subscripts for the single subscript form of arrays used to store data for user-specified subsections of the simulated roadway. I = 1 for initial position XIP; I = 2 for final position XN.
IDAT1	Unsubscripted form of IDAT(1).

Name	Description
IDAT2	Unsubscripted form of IDAT(2).
IDUM	Leading subscript for spot data station tested or employed. (Note flow direction JD is second subscript.)
IST(J)	Station number upstream or equal to vehicle position: J = 1 for initial position XIP; J = 2 for final position XN.
ITES	Code for previous test result in search for upstream/coincident station.
J	Index for loop. J = 1 for XTES = XIP; J = 2 for XTES = KN.
XTES	The vehicle location for which the upstream/coincident station number is sought (ft).

i. Modifications from TWOWAF: None, new routine in TWOPAS. However, CXSTA directs collection of some data previously collected and processed in other routines in TWOWAF.

j. Error messages: None.

18. Subroutine DBSPT(IPUP)

a. Purpose: Adds to data accumulators and counts for user-specified subsection data (between spot stations).

b. Approach: This routine is called while data from a given vehicle review is still available and CXSTA has determined that data should be stored for the subsection designated by IPUP. The routine determines the vehicle category of the vehicle in process and accumulates speed data, vehicle review counts, reviews unimpeded, reviews near desired speed, lane changes, and multilane or single lane passes.

c. Synopsis: Stores data for user-specified subsections from one vehicle review.

d. Assumptions: Passes in multilane sections are based on a comparison of the data in the regional table for the vehicle in process at the beginning and at the end of current vehicle review.

e. Relationship to other subroutines:

Calls: None.

Called by: CXSTA.

f. Formal parameters:

Name	Description
IPUP	Subscript for between station data to be stored. Supplied by calling routine.

g. Common blocks: BSPOT, CAR, CARA, LNCH, PS, REGA, ROA, TIM.

h. Local variables:

Name	Description
DUM	Dummy variable used to represent distance margin (ft), then time margin (sec), for lane changes to avoid the lane drop.
I	Utility integer and index of loop.
JTAB	Local variable set equal to IPUP.
KAT	Code for vehicle category: 1 = truck, 2 = RV, 3 = passenger car.
M	Subscript for lane change motivation: 1 = avoid lane drop, 2 = avoid delay, 3 = move right.

i. Modification from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

19. Subroutine DROPV

a. Purpose: When a vehicle is beyond end of simulated roadway or is found in the dropped lane downstream of a lane drop, it is to be removed from the roadway, indexed storage is returned to reserve, and pointers are reset.

b. Approach: Test for current state of vehicle in process. If vehicle in process was in a pass or a pass abort, the routine returns the extra and normal data subscript to the available list. If vehicle in process was not in pass or a pass abort, the state of the immediate follower is tested. If the immediate follower is passing the vehicle in process or aborting a pass, that maneuver is cancelled and the extra data subscript is returned to available list. The second follower is tested and processed similarly if the first is found in pass or abort. In all cases, the normal data subscript of vehicle in process is returned to the available list and pointers are reset for vehicles remaining in the simulation.

c. Synopsis: Remove vehicle from simulation, place data subscripts in available list reset pointers, and cancel pass or abort maneuvers as appropriate.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: CLEN2.

f. Formal parameters: None.

g. Common blocks: CAR, EXT, REG, ROA, VEH.

h. Local variables:

Name	Description
IDUM	Temporary symbol used in resetting pointers.
IDUM1	Temporary symbol used in resetting pointers.

i. Modifications from TWOWAF: None.

j. Error messages: None.

20. Subroutine DRPAV(IM)

a. Purpose: For vehicles in the continuing lane of an passing or climbing lane section, this routine determines if proximity to the lane drop should preclude a change to the dropped lane.

b. Approach: The routine uses the same basic logic and parameters as the deterministic part of DRPMO. The routine tests the time and distance to arrive at lane drop together with visibility of warning signs. The decision as to whether lane changes should be precluded is arrived at deterministically.

c. Synopsis: Determines if change into dropped lane should be precluded.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: AL21.

f. Formal parameters:

Name	Description
IM	Code for decision: = 0 for lane change not precluded, = 1 for lane change precluded. This code is returned to the calling routine.

g. Common blocks: CAR, DRPL, PS.

h. Local variables:

Name	Description
CAVD	Factor for the threshold distances and times employed in logic for DRPMO, motivation to avoid lane drop. CAVD is defined as 1.5 in a data statement.
SGNS	Distance warning signs may be seen. Defined as 400 ft in a data statement.
TDUM	Time to reach lane drop (sec).

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

21. Subroutine DRPMO(IM)

a. Purpose: For a vehicle in the dropped lane of a passing or climbing lane, this routine determines if the vehicle should be motivated to vacate the lane to avoid the drop.

b. Approach: A deterministic test is made first to find if vehicle should be concerned about the lane drop at all. This test incorporates the time and distance to the lane drop and the visibility of warning signs. If the deterministic threshold is passed, a probability for motivation is determined with the initial value based on either distance or projected time to the drop. Subroutine CONFD is called to supply data on potentially conflicting vehicles in the lane occupied and in the target lane. If there are essentially no conflicts, the probability of motivation to change lanes is reduced. If conflicts are projected, the probability of motivation to change lanes is increased. The final decision is made stochastically if probability is less than one. If the vehicle becomes motivated to change lanes, lane change motivation IM is returned as a positive integer and MOT is set equal to -1 and returned in COMMON/LNCH/. Once the deterministic threshold is passed, the probability test for lane change motivation will normally be made each review.

c. Synopsis: Determines if vehicle in dropped lane should be motivated to vacate the lane.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: CONFD, RAN(4).

Called by: AL21.

f. Formal parameters:

Name	Description
IM	Code for outcome: 0 = not motivated, > 0 = motivation with value 1 to 10 proportional to calculated urgency. Returned to calling routine.

g. Common blocks: CAR, COND, DRPL, LNCH, PAS, PS.

h. Local variables:

Name	Description
CFRE	Coefficient for probability increase due to projected conflicts and to conflicts near drop. Set equal to 0.2 in a data statement.
CTRC	Coefficient for probability increase due to nearby vehicle tracking vehicle in process toward drop. Set equal to 0.2 in a data statement.

Name	Description
DHI	Upper bound of conflict time due to one potentially conflicting vehicle (sec).
DLO	Lower bound of conflict time due to one potentially conflicting vehicle (sec).
DNUM	Numerator in quotient with denominator equal to distance to lane drop. One of two possible values for base probability. Set equal to 100 ft in data statement.
DTRAC	Distance between vehicle in process and nearby vehicle tracking toward lane drop with nearly equal speeds (ft).
I	Index of loop.
J	Loop index or limit.
K	Upper bound of loop index.
KFRE(J)	Code for J^{th} time interval: = 1 if no conflict, = 0 if a conflict.
L	Index of loop.
LNA	Generic lane number for continued lane: 1 for left lane, 2 for right lane.
RAND	Random number returned by RAN(4).
TBLOC	One-half the time interval that is blocked by a single conflicting vehicle. Set equal to 2.0 sec in a data statement.
TCOC	Time until projected conflict with a vehicle in the currently occupied lane (sec). (Total block extends in time from TCOC-TBLOC to TCOC+TBLOC.)
TCTL	Time until projected conflict with a vehicle in the target lane (sec). (Total block extends in time from TCTL-TBLOC to TCTL+TBLOC.)
TDEC	One-tenth the projected time until vehicle in process arrives at the lane drop (sec).
TDUM	Projected time until vehicle in process arrives at lane drop (sec).

Name	Description
TNUM	Numerator in quotient with denominator equal to projected time until vehicle in process arrives at lane drop. One of two possible values for base probability. Set equal 4.0 sec in a data statement.
VDUM	Speed difference; speed of vehicle in process minus speed of potentially conflicting vehicle (ft/sec).

i. Modifications from TWOWAF: None, new routine in TWOPAS. Some of numerics are based on data collected by MRI at climbing lane drops on multilane facilities, together with data collected by the University of California-Berkeley at climbing lane drops on two-lane, two-way facilities with light flows.

j. Error messages: None.

22. Subroutine DSTA(ISTA,FRAC)

a. Purpose: This routine is called when Subroutine CXSTA finds that the vehicle just processed has crossed or reached a user-specified data station. The routine stores spot data from the current vehicle review.

b. Approach: The routine calculates time of crossing the station (TCC) as the sum of FRAC and current value of TIME. The routine also determines the single subscript JTAB for the station crossed from the directional subscript ISTA and determines the vehicle category. The routine uses data from the current vehicle review to: increment vehicle counter for the appropriate vehicle category, increment counts of unimpeded vehicles and vehicles near desired speed, increment delay rates, increment platoon data or adjust status, and assemble spot speed data.

c. Synopsis: Stores spot data from vehicle review when a user-specified data collection station is crossed.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: CXSTA.

f. Formal parameters:

Name	Description
FRAC	Fraction of review interval prior to crossing station.
ISTA	Directional subscript of station.

g. Common blocks: CAR, KATPL, KTES, LNCH, NLANS, PLHDWY, REG, ROA, SPOT, STAT, TIM, VEH.

h. Local variables:

Name	Description
JTAB	Single subscript for spot data station arrays.
KAT	Code for vehicle category: 1 = truck, 2 = RV, 3 = passenger car.
KDUM	Vehicle category of platoon leader.
NDUM	Stores current value of NLN from COMMON/LNCH/ for recovery before return.
TCC	Simulation time when vehicle crosses user-specified data collection station (sec).
THP	Maximum time headway for vehicles considered to be platooned. Defined as 4.0 sec in executable statement.
THW	Time headway for vehicle in process (sec).

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

23. Subroutine DVOY(YDUM,VDUM,DVY)

a. Purpose: Calculates slope of a line with horizontal component YDUM, vertical component VDUM, and returns slope as DVY. Contains guards against very small denominator.

b. Approach: Test components and calculate ratio.

c. Synopsis: Calculates slope of a line.

d. Assumptions: Assigns slope as very small negative value when the numerator VDUM = 0.

e. Relationship to other subroutines:

Calls: None.

Called by: TRAJT.

f. Formal parameters:

Name	Description
DVY	Calculated slope. Returned to calling routine.
VDUM	Vertical component. Supplied by calling routine.
YDUM	Horizontal component. Supplied by calling routine.

g. Common blocks: None.

h. Local variables: None.

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

24. Subroutine EGAP(TL,AMX,AMN)

a. Purpose: Attempts to select a gap and quantify the parameters for a lane change during the review in process for the vehicle in process.

b. Approach: The maximum and minimum accelerations are used to calculate the maximum and minimum positions and speeds the vehicle in process might achieve at end of the review. Candidate gaps are examined beginning with the first unprocessed vehicle in target lane as new follower; the search continues forward until the foremost accessible gap. The first test for a candidate gap is the simple requirement to have 4-ft final clearance with target lane vehicles when the most favorable acceleration is used. Subsequent tests consider dynamic interactions of the vehicles involved by requiring that a specified limit risk level not be exceeded.

If vehicle in process cannot clear the first unprocessed vehicle in target lane, the search is made to the rear of that vehicle.

Only one gap is examined with the complete dynamic requirements. If a satisfactory gap is found, the acceleration for the interval is set to the maximum level that is consistent with subsequent acceptable risk in the target lane. The vehicle is then advanced and moved into the target lane.

If logic fails to find a lane change, the vehicle in process is not advanced in this routine.

c. Synopsis: The routine searches for a gap in the target lane that can be entered at the conclusion of the review in process while observing performance, preference, and risk restraints. The vehicle is advanced by this routine only if a lane change is made.

d. Assumptions: It is assumed that the risk level code IA has been set. The review interval is assumed to be short enough so that: (1) opportunities are not significantly reduced by dealing exclusively with the end of review conditions and (2) the range of positions and speeds achievable by the end of the review period will permit access to only one gap.

e. Relationship to other subroutines:

Calls: GAP, GAPC.

Called by: AL21.

f. Formal parameters:

Name	Description
AMN	Minimum acceleration to be used during review to achieve mesh with target lane gap. (Includes effects of reason for lane change motivation (ft/sec^2) and lane change urgency. Vehicle capability is always a limit.)
AMX	Maximum acceleration to be used during review to achieve mesh with target lane gap (ft/sec^2). (Vehicle performance is always a limit. The maximum acceleration may be moderated by driver acceleration preference or by the dynamic proximity of the current lane leader.)
TL	Generic number of the target lane: 1 = left lane, 2 = right lane.

g. Common blocks: CAR, CARA, LNCH, MMXF, REGA, ROA, TIM, VC, VEH.

h. Local variables:

Name	Description
EGFN	Excess gap (ft) between lane changer and new follower if lane changer uses acceleration AMN.
EGFX	Excess gap (ft) between lane changer and new follower if lane changer uses acceleration AMX.
EGLN	Excess gap (ft) between lane changer and new leader if lane changer uses acceleration AMN.
EGLX	Excess gap (ft) between lane changer and new leader if lane changer uses acceleration AMX.
GAPFN	Gap between lane changer and new follower if lane changer uses acceleration AMN.
GAPLN	Gap between lane changer and new leader if lane changer uses acceleration AMN.
GAPLX	Gap between lane changer and new leader if lane changer uses acceleration AMX.
GPFN	Gap required between lane changer and new follower at end of review for risk acceptability if lane changer uses acceleration AMN during review.
GPFX	Gap required between lane changer and new follower at end of review for risk acceptability if lane changer uses acceleration AMX during review.
GPLN	Gap required between lane changer and new leader at end of review for risk acceptability if lane changer uses acceleration AMN during review.
GPLX	Gap required between lane changer and new leader at end of review for risk acceptability if lane changer uses acceleration AMX during review.
I	Index of loop.
ISUB	Utility variable and subscript for data of target lane vehicle examined as a new leader.

Name	Description
IVF3	Limit of loop to obtain subscript for new follower.
IVL	Regional table number of target lane vehicle tested as a new leader.
IVTL	Index of loop of regional table numbers for target lane vehicles in simple (i.e., nondynamic) tests as new leaders or followers.
IVTPL	Vehicle type code for vehicle tested as new leader in target lane.
J	Index of loop and utility variable.
KF	Code for type of test failed in tests of potential new follower: 0 = did not fail test with new follower; 1 = failed simple test (gap less than 4 ft); 2 = failed dynamic test with lane changer using AMX; 3 = failed to find acceleration and final speed satisfying risk constraints with both new follower and leader.
KL	Code for type of test failed in tests of potential new leader: 0 = did not fail test with new leader; 1 = failed simple test (gap less than 4 ft); 2 = failed dynamic test with lane changer using AMN; 3 = failed to find acceleration and final speed satisfying risk constraints with both new leader and follower.
KODG	Code for gap routine to be called: = 0 for normal risks from GAP; = 1 for higher risks from GAPC when vehicle is approaching lane drop.
MNL	Regional table index for farthest back potential leader in target lane that lane changer could get in back of. (Can be equal to 1, but change will then be attempted in next forward gap behind the second vehicle in the regional table.)
MXF	Regional table index for farthest forward potential follower in target lane that lane changer could get in front of. (Can be equal to but change will then be attempted in next rearward gap in front of the fifth vehicle in the regional table.)

Name	Description
UL	Speed of potential new leader.
VF	Speed of potential new follower.
VFA	Code for range of acceptable final speed of lane changer for acceptable risk with new follower: = 10. if acceleration AMN leading to speed VMN is OK; = -1. if acceleration and speed must be greater than AMN and VMN.
VFO	Minimum speed for lane changer to provide risk acceptance with new follower.
VL	Speed of potential new leader.
VLA	Code for range of acceptable final speed of lane changer for acceptable risk with new leader: = 10. if acceleration AMX leading to speed VMX is OK; = 1. if range of lane changer final speeds must be reduced for satisfactory risk with new leader and EGLX<EGLN; = -1., same meaning as +1. but EGLN<EGLX (not expected).
VLO	Final speed of lane changer that just satisfies risk with respect to new leader (i.e., maximum acceptable final speed.)
VMN	Final speed of lane changer using AMN, the minimum acceleration during review.
VMX	Final speed of lane changer using AMX, the maximum acceleration during review.
VTL	Speed of first unprocessed vehicle (i.e., the third vehicle in the regional table) in target lane.
XMN	Projected position of lane changer at end of review if minimum acceleration AMN is used during the review interval.
XMX	Projected position of lane changer at end of review if maximum acceleration AMX is used during the review interval.
XTL	Projected position of first unprocessed vehicle (i.e., the third vehicle in the regional table) at the end of the review.

i. Modifications from TWOWAF: None, new subroutine in TWOPAS.

j. Error messages: None.

25. <u>Subroutine ENQUE</u>

a. Purpose: Prior to beginning of the simulation run, ENQUE generates an array XHEAD containing the vehicles that will enter the simulated road in each direction of travel during the simulation run.

b. Approach: For each direction, the user-specified values for flow rates and percent of vehicles following in platoons are used to determine and test the entering traffic stream. The parameters of the Borel-Tanner distribution for platoon size are calculated and the cumulative probability distribution for sizes 1 through 29 are calculated and normalized, with cumulative probability equal to 1.0 for a platoon size of 29 vehicles. The number of vehicles to be generated is calculated and tested against dimensioned array limits.

For each direction, the entering streams are generated by the following steps:

- Establish platoon size stochastically in range from 1 to 29 (note that platoon sizes of 1 represent free vehicles).
- Select leader vehicle type and driver type stochastically.
- Select leader's time headway stochastically from negative exponential distribution.
- Pack the vehicle, driver, and time data in one element of the XHEAD array.
- Advance vehicle and time accumulations.
- If platoon size greater than one, generate following vehicle type and driver type for each vehicle stochastically and assign each following vehicle a 2-sec headway.
- Pack each following vehicle's data in one element of the XHEAD array.
- Advance vehicle and time accumulations.
- Terminate vehicle generation loop when target number generated and stored; otherwise, loop back to platoon size selection.

- Add one vehicle at a time beyond simulation duration.
- Reprocess the entire directional entry array to adjust intraplatoon headways, if necessary, so that followers have at least sufficient headway for steady following at 50. ft/sec. In this process, some vehicle headways within platoons are reduced to 1 sec and others are increased to 3 sec. This reprocessing also adjusts long headways to make total flow rate correspond more closely to user-specified flow rate.

It should be noted that the order of each entering platoon will be modified, if necessary, in Subroutine EPLAT to place the vehicle with the slowest speed in the user-specified upstream alignment as the platoon leader.

The pass acceptance factors ZPASPL(JD) are also calculated in this routine. Note that all stochastic decisions in generating the entering traffic stream for direction JD are made using random numbers from RAN(JD).

c. Synopsis: Generates, tests, and stores the entering traffic streams according to specified flow rates, population compositions, and percent followers in platoons for each direction. Calculates ZPASPL(JD), a pass acceptance factor.

d. Assumptions: Interplatoon headways are assumed to follow a negative exponential distribution. Headways within platoons are initially 2 sec, but are adjusted by the car-following routine, CRFW2, as soon as the entering vehicles come onto the simulated roadway.

e. Relationship to other subroutines:

Calls: RAN, EXIT.

Called by: PROCI.

f. Formal parameters: None.

g. Common blocks: BKPM, ROA, SPE, TIM, VC, XCOUNT, XHEAD, XHMAX, XPPL, ZK, ZPASPL.

h. Local variables:

Name	Description
ALPHA	Parameter in Borel-Tanner distribution for platoon size.
AMPL	Parameter in Borel-Tanner distribution for platoon size.
DUM	Utility variable.

Name	Description
FIH	Time headway in floating-point form (sec).
I	Count of number of vehicles generated for direction in process. Subsequently in headway checks, I represents the array subscript of vehicle with headway being checked.
IH	Time headway with units of sec*1,000.
IHEAD	Array in which original entering traffic stream data are stored prior to headway checks and headway adjustments.
IHH	Holds original headway if it can be reduced. Used subsequently if headway is adjusted for time scale factor.
IHM	Minimum time headway for steady following at speed of 50-ft/sec has units of sec*100.
IHN	Holds IH value temporarily.
IH1	Original headway, stored in IHEAD.
IKDT	Driver type code in range from 1 to 10. (Note: packing would permit 1 to 16.)
IKVT	Vehicle type code in range from 1 to 13. (Note: packing would permit 1 to 32.)
IMIN	Minimum time headway if not otherwise constrained to larger value. Defined equal to 1 in an executable statement.
IOLD	Subscript of XHEAD array for leader of vehicle undergoing headway check for adequacy.
IPLEN	Number of vehicles in platoon. Decremented as vehicles are generated.
IRES	Reserve of time assignable to increase headways.
IRN	Random number with range 0 to 1,000.
ISCALE	Factor, applied to initially adjusted headways to provide specified flow rate in entering queue.

Name	Description
ITOTT	Time to be simulated plus 10 sec, in units of sec*100.
ITV	Number of vehicles to be generated for direction in process.
JTV	Count of vehicles generated, without regard to direction.
K	Index of loop.
KDT	Driver type code in range from 1 to 10.
KFACT	Factorial of loop index.
KK	Index of loop.
KTOLD	Vehicle type code for leader of vehicle undergoing check for headway adequacy.
KVT	Vehicle type code in range from 1 to 13.
K1	Loop range limit for XHEAD and/or IHEAD subscripts.
K2	Loop range limit for XHEAD subscripts.
K3	Index of loop.
RN	Random number in range from 0 to 1.0.
SUMH	Cumulative sum of time headways assigned for direction in process (sec).
TOTTIM	Total time to be simulated (sec).
WHMAX	Logical variable. True if sum of specified entering vehicles exceeds array size minus 2.
XFOLL	User-specified percentage of entering vehicles specified as following in platoons for direction in process.
XFREE	Calculated percent of entering vehicles that are free vehicles (i.e., not leaders or followers) for direction in process.
XHMEAN	Mean time headway (sec) for free vehicles and platoon leaders for direction in process.

Name	Description
XLEAD	Calculated percent of vehicles that are platoon leaders for direction in process.
XLLEN	Vehicle length (ft).
XMPL	Calculated mean platoon length (including leader) for direction in process.
XPLPR(K)	XPLPR(K) represents the probability that platoon length is less than or equal to K, where K ranges from 1 to 29 and XPLPR(29) = 1.0.
XPROB	Calculated increment for XPLPR array.

i. Modifications from TWOWAF: The logic in this routine logic is new. It enables specification for the percent of traffic platooned in the entering traffic streams, which was not possible in TWOWAF. Historically, the initial TWOWAF model generated entering vehicles as they were needed during the simulation. In the work on NCHRP Project 3-28A, KLD inserted logic in subroutine PROCI to generate and store the entering traffic streams prior to simulation processing. The entering traffic stream logic in TWOPAS has been placed in a separate routine, ENQUE, that is called by PROCI.

j. Error messages: There are two error messages. In each case, EXIT is called to terminate the run.

Message	Interpretation
Total vehicles to be generated XHD(1) + XHD(2) exceed XHEAD array size XHMAX.	The total simulation time and the specified flow rates are too large for dimensional arrays XHEAD and IHEAD.
Specified percent platooned = XFOLL not feasible at specified flow rate SFLO (JD) VPH.	Calculation of platoon characteristics has found that percent free vehicles is ≦ 0., or, that the mean time headway for free vehicles and platoon leaders would be ≦ 4.5 sec.

26. Subroutine ENTR(IEMTF)

a. Purpose: This routine is called during the simulation processing when a vehicle is scheduled to enter in the direction just processed. The routine selects the entry speed, resets pointers, and calls VGEN to provide the next extry vehicle in direction processed. Entry of a vehicle will be postponed only if an adequate gap is not available.

b. Approach: Data for the vehicle to enter are available under subscript NXI(JD), where JD is the direction of travel. Entry speed is taken first as the minimum of desired speed or specified maximum entry speed. Interaction with immediate leader is tested to determine state, free or impeded. If impeded, speed is reduced to leader speed but not less than one-tenth the mean desired speed. If speed would be less than one-tenth of the mean desired speed, speed is advanced to mean desired speed. The available gap is then tested with the revised speed and entry is postponed if the gap is still inadequate. If the vehicle entered, pointers are reset, Subroutine VGEN is called to establish next entry vehicle, and the upstream dummy in the appropriate direction of travel is flagged with a negative speed to show it was "passed" by vehicle entered.

c. Synopsis: Places scheduled entry vehicle in traffic stream on simulated roadway, if possible; performs associated pointer revisions; and calls VGEN to identify next entry in the same direction of travel. Otherwise, holds entry and advances count of directional entry delays.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: VGEN.

Called by: Main program (TWOPAS).

f. Format parameters:

Name	Description
IEMTF	Flag, = 1 for vehicle entered; = 0 for vehicle not entered.

g. Common blocks: AKPM, ALL, CAR, GEN, PAS, PLAT, ROA, TIM, VEH, VEL, VC, XCOUNT, XHEAD, ZFFX, ZK.

h. Local variables:

Name	Description
IDUM	Subscript entering vehicle.
IDUM1	Subscript for immediate leader of vehicle entering.
IKS	State to be assigned to entering vehicle.
IV	Speed assigned in test for headway adequacy (ft/sec).

Name	Description
IVDNR	Speed stratum of follower (from VDNR) for array ZFFX.
IVN	Speed stratum of leader (from VN) for array ZFFX.
IVT	Vehicle type code for entering vehicle.
RKP	Time gap (sec) in tests for usable gap.
RV	Candidate entry speed (ft/sec).

i. Modifications from TWOWAF: This routine contains the basic logic developed by KLD in NCHRP Project 3-28A when the original TWOWAF routine was replaced. Modifications in TWOPAS from the KLD version include provision for a different procedure to accommodate postponed entries using the array NSQEZ(JD). The statement to flag the speed of the upstream dummy by making it a negative number was also added to ensure that oncomers in passes would "see" the newly entered vehicle.

j. Error messages: None.

27. Subroutine EPLAT(JD)

a. Purpose: For traffic streams entering simulated road, this routine selects and places as the leader of each platoon the vehicle which would logically be the leader based on overall free speeds in the user-specified upstream alignments.

b. Approach: The routine examines the streams of traffic due to enter as configured in subroutine ENQUE. These streams, packed in array XHEAD(J), contain the vehicle type, driver type, and time headway for each entering vehicle. The data are unpacked, placed in arrays KVTE(I,JD), KDTE(I,JD), and THWE(I,JD) with I = 1 for platoon leader generated by Subroutine ENQUE. The unpacking is stopped when the end of the current platoon is found or when 29 of 30 array elements have been filled.

Each unpacked vehicle is assigned a desired speed which is stored in array DSPE(I,JD).

The unpacked platoon is then processed using subroutine UPSS to find which vehicle would have had the lowest overall free speed in the user-specified upstream alignment. The slowest upstream vehicle is placed in the platoon leading position. The headways of vehicles in the platoon are adjusted, if necessary, to compensate for differences in driver type and vehicle length in the reordered platoon.

c. Synopsis: The entering traffic streams in XHEAD(J) are unpacked one platoon at a time for each direction; desired speeds are assigned stochastically; the upstream free speeds for each vehicle in the platoon are estimated; and the slowest vehicle in the user-specified upstream alignment is shifted to the platoon leader position.

d. Assumptions: Dimensioning for the arrays of unpacked entering streams assume that platoons will not exceed 29 vehicles in length. For longer platoons in the packed data, only the first 29 vehicles will be examined for slowest upstream speed. Note, however, that the logic in Subroutine ENQUE currently limits platoons to a maximum length of 29 vehicles.

e. Relationship to other subroutines:

Calls: UPSS, VASGN.

Called by: VGEN.

f. Formal parameters:

Name	Description
JD	Direction of travel for entering traffic stream. Supplied by calling routine.

g. Common blocks: PLAT, VC, XCOUNT, XHEAD, ZER.

h. Local variables:

Name	Description
DUM	Length of vehicle (ft) for the original platoon leader being shifted to a position back in the platoon.
DUM1	Length of vehicle moved to lead position (ft); also used later in the routine to represent the increase in time gap for the second vehicle in the platoon (sec).
DVE	Desired speeds of vehicles in platoon.
I	Utility variable.
IH	Time headway, in units of sec*100.
IPM	Number of vehicles in platoon, including leader; may be equal to one for platoons consisting of a single free vehicle.

Name	Description
IPX	Leading subscript of platoon arrays (KVTE, KDTE, DSPE, and THWE) for vehicle with lowest upstream speed.
J	Leading subscript of platoon arrays (PLAT).
KDT	Driver type code.
KVE	Vehicle type code.
KVT	Vehicle type code.
MXPT	Time headway (sec) used to classify a vehicle as a platoon member, or as a platoon leader or free vehicle. Defined as 4 sec in a data statement.
SUP	Mean speed of vehicle when traveling unimpeded in upstream alignment.
SUPX	The minimum speed found for vehicles in the upstream alignment.

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

28. Subroutine ERASE2

a. Purpose: To initialize variables and arrays which will be used to store data.

b. Approach: Arrays are initialized under the control of DO loops.

c. Synopsis: See Approach.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: Main program (TWOPAS).

f. Formal parameters: None.

g. Common blocks: blank, BSPOT, KATPL, SMR, SPOT, TIM.

h. Local variables:

Name	Description
I	Index of loop.
J	Index of loop.
JJ	Index of loop.
K	Index of loop.
KKJP	Index of loop.

i. Modifications from TWOWAF: This routine was named ERASE in program TWOWAF. It has been changed to include new variables and to include added dimensions for original variables.

j. Error messages: None.

29. Subroutine EXOUTP

a. Purpose: To provide final form output for data that were generated during a user-specified portion of the simulation test time.

b. Approach: The data for part of the "test time" were written onto a file on Unit 4 (by other routines) at user-specified intervals. This routine rewinds file and reads a complete set of data from Unit 4. It then calls Subroutine FPUT2 which processes the data to final form. The routine keeps reading and processing data sets from Unit 4 until an end-of-file is found. On finding the end-of-file, the program branches to EXIT.

The extra final output feature implemented in this routine was available in TWOWAF, but has not been updated in TWOPAS. Therefore, it does not contain any output data for passing or climbing lane sections. The use of this feature is not recommended for any run in which the simulated roadway contains a passing or climbing lane.

c. Synopsis: Reads sets of simulation data from Unit 4 and manages processing and printing of these data by calls to FPUT2.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: FPUT2.

Called by: REED.

f. Formal parameters: None.

g. Common blocks: Blank, CAR, PAG, PCT, ROA, SCR, SMR, SPE, TIM, TOP, VEL.

h. Local variables: None.

i. Modifications from TWOWAF: Minor adjustments to COMMONs.

j. Error messages: None.

30. <u>Subroutine FAILG</u>

a. Purpose: FAILG is called when: (1) the vehicle in process in an added passing or climbing lane section is motivated to change lanes either to move left to avoid delay or to avoid lane drop; and (2) the vehicle in process has failed to find an acceptable lane change in current review in Subroutine EGAP. FAILG tries to find a gap which the vehicle in process might enter after several reviews (up to 10 sec in the future) and, if such a gap is found, the routine calculates an algebraic acceleration within vehicle capability and driver preferences that will improve future access to the gap. If FAILG does not find a workable future gap and the vehicle is approaching a lane drop in the closed lane, the vehicle is processed with a deceleration that will prevent running through the end-of-lane.

b. Approach: The routine initiates a counter IGAPX that limits the number of gaps examined in detail to two. FAILG determines the maximum speed decrease that would be acceptable to the end of a multi-review gap pursuit; this speed decrease is dependent on lane change motivation and other variables. FAILG calls TJCLL to obtain projected speeds and positions of current lane leader. FAILG selects a target gap for examination either: (1) from data on new lane follower identified by FAILG in previous review; or (2) from failure data generated by EGAP in this review. FAILG calls GDATA to project available gaps at future times and begins examinations through future time for possible lane changes at 2-sec intervals. FAILG calls GTRIM to calculate the future acceptable entry positions and speeds using the data from GDATA and the constraints due to limits on acceptable speed decreases the projected position and speed of the current lane leader, and the position of the lane drop, if any. GTRIM may return a code indicating that a particular gap will be unworkable at the time tested. If GTRIM determines that a particular gap may possibly be acceptable at the future time tested, FAILG then calls TRAJT to determine if acceptable gaps entry speed and positions can be achieved by vehicle in process at the specified future time. If so, FAILG advances the vehicle in process according to findings. If not, FAILG determines from the TRAJT failure data if the same gap should be reexamined 2 sec later in time, subject to a 10-sec limit. If so, FAILG advances future time and loops back to GTRIM. If not, FAILG determines if one more potential gap should be examined. If two future gaps fail and the lane change motivation is to avoid the lane drop, FAILG determines an appropriate response to the approaching lane drop; otherwise, the vehicle is not advanced by FAILG since no acceptable lane change has been found.

c. Synopsis: FAILG determines if vehicle in process can adjust its speed to maneuver into a gap in the other lane within 2 to 10 sec. If so, FAILG starts or continues the vehicle in process on a path to pursue and enter that gap. FAILG also advances vehicles that must begin or continue deceleration to avoid the lane drop at the end of an added passing or climbing lane.

d. Assumptions: It is assumed that usable future gaps can be identified and the associated pursuit trajectories can be quantified by examining projected conditions at 2, 4, 6, 8, and 10 sec into the future. (Recall that EGAP has already examined conditions at the end of the current review interval, usually 1 sec into the future.)

e. Relationship to other subroutines:

Calls: GDATA, GTRIM, TJCLL, TRAJT.

Called by: AL21.

f. Formal parameters: None.

g. Common blocks: CAR, CARA, GDAT, IPTAR, LNCH, MMXF, PLD, PS, QUA, REG, REGA, TIM, VEH.

h. Local variables:

Name	Description
AAEOL	Deceleration (a positive value) normally used by the driver type in process when blocked and approaching a lane drop (ft/sec^2).
AFW	Formal parameter in calls to Subroutine GDATA. AFW is equal to 1.0 when gap follower has been processed; AFW is equal to 0.0 when gap follower has not been processed.
ALD	Formal parameter in calls to Subroutine GDATA. ALD is equal to 1.0 when gap leader has been processed; ALD is equal to 0.0 when gap leader has not been processed.

Name	Description
DUM	For vehicles approaching the lane drop, DUM is a bias added to a speed difference used in making the decision to look forward or rearward for gaps (ft/sec).
DV3	A speed difference, calculated as the speed of vehicle in process minus speed of first unprocessed vehicle in the target lane (ft/sec).
I	Index of loop.
IDUM	Utility variable used to represent indices of vehicles in the target lane.
IGAPX	Count of gaps examined in detail. Value includes gap in process.
IPTR	Index of vehicle in target lane that is potential new follower in the multi-review pursuit of a lane change gap.
NLLD	Index of new lane leader.
NLTAR	Regional table position number of potential follower in target lane.
TTOD	Time (sec) for vehicle in process to reach the lane drop at current speed or at a minimum speed of 5 ft/sec.

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

31. Subroutine FLIN2

a. Purpose: This routine processes data for a vehicle which has been advanced and has been found to cross or reach the "finish line" (i.e., the downstream point on the roadway where data collection ends in a given direction of travel). Note: The finish line is located at the farthest downstream user-specified data collection station, located at coordinate XSTA(MS,JD), where MS = MSTA(JD). The overall test section for which data are collected in each direction lies between the most upstream specified data station at XSTA(1,JD) and XSTA(MS,JD).

b. Approach: When a vehicle crosses the finish line, the time at which that vehicle crossed the start line (TIN) is unpacked from TVIN(IP). If TIN is greater than zero (which indicates that the vehicle in process crossed the start line during the simulation), overall data for that vehicle are stored. Spot data are stored for all vehicles crossing the finish line during the test time, whether or not they crossed the start line during the test time.

c. Synopsis: FLIN2 processes and stores data for a vehicle that reaches or crosses the finish line of the overall test section during test time.

d. Assumptions: This routine assumes that the vehicle in process has been found to have reached or crossed the finish line during the current review interval, and the current time is greater or equal to warmup time. These assumptions are tested in the calling routine CXSTA.

The maximum simulation time in sec*10 is assumed to not exceed the maximum size of a real number when packed in the leading digits of a real number above 10,000.

e. Relationship to other subroutines:

Calls: None.

Called by: CXSTA.

f. Formal parameters: None.

g. Common blocks: Blank, CAR, LNCH, PLHDWY, ROA, SMR, STAT, TIM, TVIN, VEH, VEL.

h. Local variables:

Name	Description
IDD	Temporary storage for cumulative count of platoon length currently crossing the finish line prior to vehicle in process.
IDUM	Subscript for platoon length stratum.
IHDW	Subscript for headway stratum in which value T falls.
IVCAT	Code representing vehicle category and direction of travel (subscript for single dimensional array of six elements representing three vehicle categories and two directions of travel).
JM	Code for direction of travel minus 1.
JVT	Code representing vehicle type and direction of travel (subscript for single dimensional array of 26 elements representing 13 vehicle types and two directions of travel).

Name	Description
KVCAT	Single direction vehicle category.
MS	Subscript for data station that is the finish line in the direction of travel in process.
O	Temporary storage for normal desired speed of vehicle in process (ft/sec).
SPDO	Overall speed of vehicle in process (ft/sec).
T	Time headway of vehicle in process at the finish line (sec). Note: In an added passing or climbing lane section, T is measured to the leader of the vehicle in process in same lane.
TOA	Overall travel time, start line to finish line, for vehicle in process (sec).
TOUTN	Simulation time when vehicle in process crossed finish line (sec).
XOALL	Distance, start line to finish line, in direction being processed (ft). XOALL is subscripted by direction.

i. Modifications from TWOWAF: This routine replaces subroutine FLINE used in TWOWAF and contains essentially the same logic. Modifications include provisions for the possibility of an added passing or climbing lane at the finish line.

j. Error messages: None.

32. Subroutine FPUT2

a. Purpose: Print simulation results in final form.

b. Approach: FPUT2 is primarily a supervisory routine which calls others in sequence to process and print data.

c. Synopsis: Manages final printed output.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: PAGE1, PAGE2, PAGE3, PAGE4, PAGE5, PAGE6, PAGE7, PAGE89, POUT, SOUT.

Called by: Main Program (TWOPAS), EXOUTP.

f. Formal parameters: None.

g. Common blocks: Blank, CMTOUT, NLANS, PCTOUT, PMOUT, ROA, SAVOUT, STAT, TIM, TOP, TTIOUT, TTMOUT, TTSOUT, UND.

h. Local variables:

Name	Description
I	Index of loop.
IDUM	Temporary storage for data subscript, JCDA(I,JD), last found in search.
J	Index of loop.
JTAB	Bidirectional subscript for user-specified spot data collection station to be processed. Subscripts 1 through 20 are reserved for Direction No. 1; 21 through 40 are reserved for Direction No. 2.
JU	Index for sequence of minus signs.
KTAB	Bidirectional subscript for user-specified subsection. Subscripts 1 through 10 are reserved for Direction No. 1; 11 through 20 are reserved for Direction No. 2.
MX	Maximum spot data collection station number used in direction processed.
NU	Upper range for index in print of minus signs.
UNDEF	Defined as minus sign by Hollerith format in a data statement.

i. Modifications from TWOWAF: This routine replaces subroutine FPUT used in TWOWAF. FPUT2 contains the original logic of FPUT and two additional loops. The first loop calls for the printing of one-page summaries from spot data stations in Direction No. 1 and then Direction No. 2. The second loop calls for the printing of one-page summaries from the specified subsections of the simulated roadway.

j. Error messages: None.

33. Function FRAK(X1,X2,XB,V1,V2,DT)

a. Purpose: Calculates FRAK as the fraction of the review interval DT spent traveling from X1 to XB.

b. Approach: Calculates FRAK as the ratio of distances (XB-X1)/(X2-X1). The function contains a guard against a zero denominator in this expression.

c. Synopsis: Calculates fraction of review interval spent upstream of XB when travel in review was X1 to X2.

d. Assumptions: It is assumed that any speed change from V1 to V2 during the review interval of time length DT will not appreciably alter the value of FRAK. Numerical tests with DT = 1.0 sec indicated acceptable accuracy of this assumption.

e. Relationship to other subroutines:

Calls: None.

Called by: CLEN2, CXSTA.

f. Formal parameters:

Name	Description
DT	Review interval (sec).
V1	Speed at start of review (ft/sec).
V2	Speed at conclusion of review (ft/sec).
XB	Position of boundary or station (ft).
X1	Position at start of review (ft).
X2	Position at end of review (ft).

g. Common blocks: None.

h. Local variables: None.

i. Modifications from TWOWAF: FRAK is a new routine in TWOPAS.

j. Error messages: None.

34. Subroutine FSTA(IDA,FRC)

a. Purpose: This routine is called by CXSTA when it finds that the vehicle in process has crossed/reached the downstream station of a user-specified subsection of the simulated roadway during test time. The routine increments overall data for subsection if it finds that the start station was also crossed.

b. Approach: FSTA unpacks TSTAI, the upstream start time, from TVIN(IP). If TSTAI > 0, FSTA increments the vehicle count for the appropriate vehicle category and the cumulative travel time by vehicle category.

c. Synopsis: Stores overall data for vehicle that crosses the downstream station of a user-specified subsection.

d. Assumptions: Accepts overall data for vehicles crossing the downstream station during test time without constraint on whether the vehicles crossed the upstream station during warmup time or test time.

e. Relationship to other subroutines:

Calls: None.

Called by: CXSTA.

f. Formal parameters:

Name	Description
FRC	Fraction of review prior to arrival at data station.
IDA	Bidirectional subscript for subsection data arrays; subscripts 1 through 10 are reserved for Direction No. 1; subscripts 11 through 20 are reserved for Direction No. 2.

g. Common blocks: BSPOT, CAR, TIM, TVIN.

h. Local variables:

Name	Description
KAT	Code for vehicle category: 1 = truck, 2 = RV, 3 = passenger car.
TSTAI	Simulation time at which vehicle crossed upstream station of user-specified subsection.

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

35. Subroutine FUEL

a. Purpose: Subroutine FUEL packs data that can be used to determine fuel consumptions for individual vehicle reviews into elements of FARRAY; when all 128 elements of FARRAY are filled, the array is written onto Unit 10.

b. Approach: Individual data items are scaled and biased into integer variables. They are then packed into one integer which is an element of FARRAY.

For details of packing, see the discussion of Special Features.

c. Synopsis: The following data are packed and stored for the vehicle review just processed: final speed, average acceleration, local grade, direction of travel, and vehicle.

d. Assumptions: Word length must be sufficient for an integer to contain 14 decimal digits and a sign.

e. Relationship to other subroutines:

Calls: None.

Called by: CLEN2.

f. Formal parameters: None.

g. Common blocks: CAR, FUL, ROA, VEH.

h. Local variables:

Name	Description
KAAAA	Intermediate form for average acceleration.
KGG	Intermediate form for percent grade.
KVVVV	Intermediate form for final speed.

i. Modifications from TWOWAF: None.

j. Error messages: None.

36. Subroutine FVEH(NSETD)

a. Purpose: Shift vehicles in the regional table.

b. Approach: Using the parameter NSETD, Subroutine FVEH calculates the upper limit for a loop that shifts data forward one position for vehicles in the regional table in front of the first unprocessed or just processed vehicle. This routine processes data only for the lane occupied by the vehicle just processed or about to be processed.

c. Synopsis: Shifts data forward for some vehicles in one lane of the regional table.

d. Assumptions: Shifts are made in single subscript data forms. Other logic transfers the revised values into the double subscript form.

e. Relationship to other subroutines:

Calls: None.

Called by: CLEN2, LCBOK.

f. Formal parameters:

Name	Description
NSETD	Code for shifts to be made: 1 for shift 2nd ahead to 3rd ahead position and 1st ahead to 2nd ahead position; 2 for shift 2nd ahead to 3rd ahead position. Supplied by calling routine.

g. Common blocks: REG, REUB1.

h. Local variables:

Name	Description
I	Index of loop.
IDUM	Upper limit of loop.
IDUM1	Initial subscript of data shifted forward.
IDUM2	Final subscript of data shifted.

i. Modifications from TWOWAF: None, new subroutine in TWOPAS.

j. Error messages: None.

37. <u>Subroutine GAP(UL,VF,GP)</u>

a. Purpose: Calculates the space gap (GP) associated with a leader speed (UL) and follower speed (VF) which would normally elicit a follower response specified by risk level (IA) for driver type (KDR).

b. Approach: This routine uses the table SGAP(7,7,40) previously quantified in Subroutine GENTB. The logic traps out cases with VF ≦ UL-5. for which GP is returned as 4.0 ft. For VF ≧ UL, linear interpolation is used in the SGAP table. For VF > UL-5. and VF < UL, linear interpolation is used between the value GP = 4.0 ft and the value of GP for VF=UL.

c. Synopsis: Calculates space gap between a leader-follower pair that would normally elicit a specified acceleration response by the driver type in process.

d. Assumptions: It is assumed that two-way linear extrapolation and small extrapolations in the SGAP table are acceptable.

e. Relationship to other subroutines:

Calls: None.

Called by: CHLMO, CHRMO, EGAP, GTRIM.

f. Formal parameters:

Name	Description
VF	Speed of follower (ft/sec). Supplied by calling routine.
VL	Speed of leader (ft/sec). Supplied by calling routine.
GP	Space gap between leader and follower (ft). Returned to calling routine.

g. Common blocks: LNCH, TAB.

h. Local variables:

Name	Description
CU1	Interpolation factor used with the two tabular values (from SGAP) that contain the smaller of two subscripts (JU1) for leader speed.
CV1	Interpolation factor used with the two tabular values (from SGAP) that contain the smaller of two subscripts (JV1) for follower speed.
C1	Interpolation factor for 4.0 ft in cases where leader speed is greater than follower but by less than 5.0 ft/sec.
C2	Defined as 1.0-C1, where C1 is zero for cases with VF ≧ UL.
IAKDR	Third subscript of SGAP array: linearized combination of risk level code IA and driver type KDR. IAKDR=IA+4*(KDR-1).
JU1	Smaller of subscripts for leader speed.
JU2	Larger of subscripts for leader speed.
JV1	Smaller of subscripts for follower speed.
JV2	Larger of subscripts for follower speed.

i. Modifications from TWOWAF: None, new subroutine in TWOPAS.

j. Error messages: None.

38. Subroutine GAPC(UL,VF,GP)

a. Purpose: Calculates minimum acceptable space gap (GP) given leader speed (UL) and follower speed (VF). The space gap calculated by GAPC is critically small and GAPC is called only for vehicles in the dropped lane approaching a lane drop.

b. Approach: Subroutine GAPC sets GP equal to 4.0 ft and returns this value to the calling routine if UL > VF. Otherwise, with UL < VF, GAPC adds to GP the distance required to reduce speed by VF-UL using a critical deceleration (ACRIT).

c. Synopsis: Supplies minimum acceptable space gaps for vehicles attempting to vacate a lane about to be dropped.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: EGAP.

f. Formal parameters:

Name	Description
GP	Minimum acceptable space gap (ft). Returned to calling routine.
UL	Speed of leader (ft/sec). Supplied by calling routine.
VF	Speed of follower (ft/sec). Supplied by calling routine.

g. Common blocks: None.

h. Local variables:

Name	Description
ACRIT	The deceleration used in calculating separation distance required to remove a followers' excess speed. Defined in a data statement as 10.0 ft/sec^2.

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

39. Subroutine GDATA(AFW,ALD)

a. Purpose: GDATA calculates data on the gap in front of the vehicle with index NFW. These data can be used to calculate risk acceptable speed/position combinations for the lane change at future times.

b. Approach: GDATA initiates a code KDGP = 1 indicating that a gap is potentially usable. GDATA finds for local time zero (the beginning of the current review) the most forward acceptable position for the lane changer (XLDO) and the most rearward acceptable position for the lane changer (XFWO).

If a potentially acceptable lane change cannot occur within the next 10 sec, GDATA sets KDGP = -1 and returns. Otherwise GDATA calls SSLOP to obtain the slopes (ft/sec)/(ft) of the upper and lower boundaries of the risk-acceptable region that define an acceptable path toward the possible lane change. GDATA then calculates, for local time zero, the highest acceptable speed at the rearmost position (RSPHO) and the minimum acceptable speed at the forward boundary, FSPMO. GDATA also calculates the time rates of change of the above speeds as CSPH and CSPM.

For local time zero and for 10 sec in the future, GDATA calculates the acceptable range of speeds at rearmost boundary and at the forward boundary of the risk-acceptable region. If these ranges are all small or negative, GDATA sets KDGP = -1 and returns. Otherwise control returns to the calling routine with KDGP = 1 and the above data.

c. Synopsis: GDATA returns a code indicating whether a gap is potentially usable or not. If usable, GDATA also returns data to calculate risk-acceptable speed/position combinations for the vehicle in process to reach that gap and make a lane change at some future time within 10 sec.

d. Assumptions: GDATA (1) assumes the gap leader and follower will continue at their current speeds; and (2) assumes that the upper and lower boundaries of the risk-acceptable region can be approximated as straight lines in a two-dimensional coordinate system with the abscissa equal to the position of the lane changer and the ordinate equal to the speed of the lane changer. This approximation erroneously incorporates as risk-acceptable a small position-speed area at the upper boundary and erroneously eliminates a small area below the lower boundary.

e. Relationship to other subroutines:

Calls: SSLOP.

Called by: FAILG.

f. Formal parameters:

Name	Description
AFW	Factor to adjust gap follower to beginning of review: 0 if not processed; 1 if processed.
ALD	Factor to adjust gap leader to beginning of review. Same values as above.

g. Common blocks: CAR, GDAT, IPTAR, TIM, VC, VEH.

h. Local variables:

Name	Description
DUM	Future seconds in calculations of RSPA and FSPA.
FSPA	FSPA(1) = range of acceptable speeds (ft/sec) at most forward acceptable position at the beginning of the current review; FSPA(2) = range of acceptable speeds (ft/sec) at most forward acceptable position at the beginning of the current review plus 10 sec.
I	Vehicle type code for potential new leader.
LTM	Index of loop.
NLD	Index of potential new leader.
RSPA	RSPA(1) = range of acceptable speeds (ft/sec) at most rearward acceptable position at the beginning of the current review; RSPA(2) = range of acceptable speeds (ft/sec) at most rearward acceptable position at the beginning of the current review plus 10 sec.
XGPO	Range of acceptable positions (ft) at beginning of the current review.

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

40. Subroutine GENTB

a. Purpose: GENTB calculates a table of space gaps with conceptual format SGAP(JUL,JVF,IA,IDR) where: JUL is the subscript for leader speed, where speed is equal to (JUL-1)*20,JUL=1,7; JVF is the subscript for follower speed with the same range and speed equivalence; IA is a code for the risk level (for IA = 1, follower would use -5.0 ft/sec^2, IA = 2 represents -10.0 ft/sec^2, IA = 3 represents -15.0 ft/sec^2, and IA = 4 represents 0.0 ft/sec^2); and, IDR is a code representing driver type in the range from 1 to 10.

b. Approach: Array values are calculated in a set of nested loops. The algebraic forms and numerical coefficients correspond to those that are employed to calculate follower response in Subroutine CRFW2. To observe the restriction to three subscripts on arrays for some FORTRAN compilers, the IA and IDR subscripts are linearized to IAIDR=IA+4*(IDR-1), and the table is actually computed as SGAP(JUL,JVF,IAIDR).

c. Synopsis: Calculates the space gap table SGAP.

d. Assumptions: It is assumed that the risk levels, represented by IA ranging from 1 to 4, correspond to leader-follower interactions that will be needed in gap appraisal.

e. Relationship to other subroutines:

Calls: None.

Called by: Main Program (TWOPAS).

f. Formal parameters: None.

g. Common blocks: BKPM, RAMAX, REUB3, RMISC, RVMAX, TAB, YTRACE, ZK, ZVC.

h. Local variables:

Name	Description
ACS	The follower response, i.e., acceleration (ft/sec^2), for which the gap is sought.
COEF1	An intermediate value in tests for Case 1 (ft/ft).
DADYO	Rate of change of acceleration with position evaluated at position where acceleration is zero.
DX	YC-YX, distance from Case 1 zero acceleration to emergency stopping limit (ft).
DZ	YC-YZ, distance from Case 1 zero acceleration position (according to revised KLD-Pitt model) to emergency stopping limit (ft).
ETA	Coefficient, defined equal to 0.3 in a data statement.
FA	Combination of FAC and other functions.
FAC	The acceleration required to remain at the critical stopping condition (ft/sec^2).
FAZ	Acceleration required to remain at the zero acceleration condition of the improved KLD-Pitt model (ft/sec^2).

Name	Description
GAPO	The steady following gap at leader speed (ft).
IA	Code for acceleration risk level: 1 for -5.0 ft/sec^2; 2 for -10.0 ft/sec^2; 3 for -15.0 ft/sec^2; and 4 for 0.00 ft/sec^2.
IAIDR	Linear combination of subscripts. IAIDR= IA+4*(IDR-1).
ICALT	ICALT(I,J,K) is the Case type found in calculation of SGAP(I,J,K). Used in testing and debugging. See definition of Case type for ITYP in Subroutine CRFW2.
IDR	Code for driver type, in range from 1 to 10.
IK	Integer form for leader speed or follower speed (ft/sec).
JUL	Subscript for tabulated leader speed: leader speed = 20*(JUL-1).
JVF	Subscript for tabulated follower speed: follower speed = 20*(JVF-1).
RAK	Car-following coefficient for driver type in process. (Note: RAK=BKPM(IDR)).
REE	Emergency stopping deceleration; defined as 15.0 ft/sec^2 in a data statement.
RKU	Steady following time gap at leader speed (sec).
RKV	Steady following time gap at follower speed (sec).
RTAU	Time step minus driver response delay (sec).
RVF	Tabular value for follower speed (ft/sec).
RVLN	Tabular value for leader speed (ft/sec).
SAC(IA)	The acceleration values to be used in calculating SGAP. Defined in a data statement as -5., -10., -15., and 0.0 for IA = 1,4.

Name	Description
VMN	A leader speed below which KKU=2.0. Defined in a data statement as 5.0 ft/sec.
YC	Relative position where follower would be in emergency stopping condition.
YDO	Calculated position for follower, measured relative to follower position for steady following at the leader's speed (ft).
YDZ	Relative position of follower (relative to steady-following position at leader speed) where acceleration would be zero according to the improved KLD-Pitt model (ft).
YX	Most advanced relative position of follower for zero acceleration in Case 1.

i. Modifications from TWOWAF: None, new subroutine in TWOPAS.

j. Error messages: None.

41. Subroutine GTRIM

a. Purpose: GTRIM is called by FAILG and is part of the search for an acceptable gap for a lane changer to enter at a future time within the next 10 sec. GTRIM defines the remaining risk-acceptable speed/position combinations at TTCL seconds in the future after imposition of the following constraints: (1) position and speed of current leader in same lane; (2) location of lane drop; (3) maximum speed; and (4) preferred minimum speed. GTRIM also returns a code (KFAIL) indicating whether the gap under consideration is potentially usable at time TTCL.

b. Approach: The risk acceptable region for future access to a gap in the target lane is defined by the apexes of the region in a conceptual two-dimensional plane where position is abscissa and speed is ordinate. The position and speed values for the apexes are XX(N) and VV(N), and the associated weight factors are RWT(N),N=1,8. The value of RWT is 1.0 for apexes that are in use and should be heavily weighted in calculation of an approximate centroid of the risk-acceptable region. The value of RWT is 0.01 for apexes that are in use, but should be given only small weight in centroid calculation. The value of RWT is 0.0 for apexes not in use.

GTRIM initializes KFAIL = 0, signifying a satisfactory outcome. The values of the primary apexes (subscripts 1, 3, 5, and 7) are set using data from GDATA. Following numbered statement 70, GTRIM begins to test and "trim" the risk-acceptable region using the constraint imposed by the preferred speed. At numbered statement 180, GTRIM begins to test and trim the region considering the preferred minimum speed. At numbered statement 300, GTRIM begins to test and trim the region due to constraints from the position and speed of the current lane leader or from the lane drop. At appropriate points, GTRIM makes tests on the usefulness of the remaining region. If the usefulness of the remaining region is very small or nonexistent, GTRIM sets the KFAIL code greater than 0 with the following meanings:

KFAIL	Meaning
0	Gap potentially usable.
1	Range of acceptable positions is too small initially or after imposition of the maximum speed constraint.
2	Range of acceptable positions is too small after all trimming completed.
3	Acceptable speeds are all above the preferred maximum speed.
4	Acceptable speeds are all below the preferred minimum speed.
5	Acceptable speeds and positions are inaccessible due to constraints from current lane leader or the lane drop.

c. Synopsis: For a specific gap and a specific future time, GTRIM provides a code indicating whether or not the gap is potentially usable by the lane changer. If the gap is potentially usable, GTRIM provides data for the then acceptable positions and speeds for the lane changer, including effects of constraints imposed by driver speed preferences, the position and speed of the current lane leader and the location of the lane drop.

d. Assumptions: A straight-sided quadrilateral in the position-speed plane is assumed to be an adequate initial approximation for risk-acceptable conditions.

e. Relationship to other subroutines:

Calls: CROSS, GAP.

Called by: FAILG.

f. Formal parameters: None.

g. Common blocks: CAR, GDAT, LNCH, PLD, PS.

h. Local variables:

Name	Description
AAEOL	Deceleration normally used by the driver type in process when trapped and approaching a lane drop.
DSFAC	Factor multiplied times normal desired speed to obtain preferred maximum speed. DSFAC is set equal to 1.1 in a data statement.
DUM	Utility variable.
GPH	Space gap (ft) required to current lane leader if vehicle in process is at maximum lane change speed, VV(3).
GPL	Space gap (ft) required to current lane leader if vehicle in process is at minimum lane change speed, VV(7).
I	Index of loop.
JJ1	An apex subscript; the smaller of two for adjacent, active apexes.
JJ2	An apex subscript; the larger of two for adjacent, active apexes.
NSEG	Index of loop. Segment number of current lane leader's projected trajectory.
SLO	Slope (ft/sec)/ft of boundary to risk-acceptable region due to position and speed of current lane leader.
VCC	Speed value where a constraint due to the position and speed of the current leader crosses a specific side of the risk-acceptable region.

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

42. Subroutine LCBOK

a. Purpose: This routine performs lane change bookkeeping. It is called when the vehicle just processed has changed lanes. The subscripted pointers and the regional table data are updated to reflect the new lane and position of the lane changer.

b. Approach: Data in COMMON/LNCH/ are used to adjust the pointers and regional table. If the lane changer has entered the target lane behind an unprocessed vehicle, then logic transfers to statement 200, and the lane changer's desired speed is set negative as a flag that its processing has been completed.

c. Synopsis: Adjusts pointers and regional table after a lane change.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: FVEH, SERT, WELD.

Called by: CLEN2.

f. Formal parameters: None.

g. Common blocks: CAR, CARA, LNCH, REG, REGA, VEH.

h. Local variables:

Name	Description
I	Index of loop.
IDM	Regional table subscript.
L	Generic number of target lane (1 = left lane, 2 = right lane).

i. Modifications from TWOWAF: None, new subroutine in TWOPAS.

j. Error messages: None.

43. Subroutine NXOCV(KSI,PRTM)

a. Purpose: NXOCV is used in processing passing maneuvers by vehicles on conventional two-lane highway sections and by vehicles in the opposing (one-lane) direction to an added passing or climbing lane. The routine identifies the next oncoming vehicle in one opposing lane or in both opposing lanes where two exist.

b. Approach: NXOCV starts its search for the next oncoming vehicle with NOV(1), the subscript of last identified oncoming vehicle in generic lane 1 of the opposing direction. The current oncoming vehicle is found using the leader and follower pointers. If this vehicle is just clearing, Code ITRY = 2 is set. NXOCV then sets NOV(1) equal to the subscript of the oncomer. If the passing zone Code (JPAS) is equal to 1, there is only one oncoming lane and logic branches to Statement 161, where IOL is set equal to NOV(1) and control returns to the calling routine. Otherwise JPAS is equal to 0, and there are two opposing lanes. In this case, the above logic is repeated to find NOV(2), the oncomer in opposing generic lane 2.

Logic continues for the case of two opposing lanes. Tests determine if only one of the two next oncomers is in sight of the vehicle in process. If so, IOL is set as the subscript of the one in sight. If both are in sight, they are tested to determine which will be most advanced after PRTM seconds, and IOL is set equal to oncomer that will be most advanced.

The oncoming vehicle IOL will be a constraining factor in pass initiation, pass completion, and pass abort decisions.

c. Synopsis: NXOCV updates NOV(JJL), for JJL=1 or JJL=1,2, as subscript(s) next oncoming vehicle(s) in opposing direction lane(s). The routine sets the Code ITRY = 2 if the vehicle in process is just clearing an opposing direction vehicle. NXOCV sets IOL as subscript of next oncoming vehicle that will influence pass initiation, pass completion, and pass abort decisions.

d. Assumptions: Subroutine NXOCV assumes that: (1) If the vehicle in process has state KSI < 5, it will already have been advanced during the review in process; if the vehicle in process has state KSI = 5, it will not yet have been advanced; (2) When two opposing lanes are present (JPAS = 0), only one oncoming vehicle is selected as influencing pass/abort decisions. The selected oncomer is the only one in sight; or, if oncomers are in sight in both opposing lanes, the vehicle selected will be closest to the vehicle in process when the pass is complete; (3) It is assumed that a passing zone on a conventional two-lane highway (JPAS = 1) with just one opposing direction lane will not be followed immediately by a pass zone JPAS = 0 with two opposing lanes; a no-passing zone (JPAS = -1) should intervene (otherwise, a passer or potential passer in the JPAS = 1 zone would need to examine potential oncomers both two opposing lanes).

e. Relationship to other subroutines:

Calls: SGHT.

f. Formal parameters:

Name	Description
KSI	The state, in single digit form, of the vehicle in process at beginning of review. Supplied by calling routine.
PRTM	Projected time (sec) until passing maneuver will be complete. Supplied by calling routine.

g. Common blocks: CAR, GEO, NOV, PAS, QUA, ROA, TIM, VC, VEH.

h. Local variables:

Name	Description
DUM	Distance (ft) from rear of vehicle in process to downstream end of simulated road.
DUM1	Remaining distance (ft) between rear of vehicle in process and a vehicle in opposing lane. DUM1 may be negative if the vehicle in the opposing lane has cleared.
ION	Subscript of opposing direction vehicle.
ISEE(JJL)	Code. ISEE(JJL) is equal to 1 or 0 depending upon whether the opposing direction vehicle is or is not in sight in opposing direction generic lane number JJL.

i. Modifications from TWOWAF: NXOCV is a new routine. In TWOWAF, the logic for finding the next oncoming vehicle in a lane was found in other routines, and was much simpler since there could be only one opposing lane.

j. Error messages: None.

44. Subroutine OPUT

a. Purpose: Print a summary of the user-specified input data for the simulation run as previously assembled by Subroutine PROCI.

b. Approach: Uses variables prepared for simulation processing and vehicle performance equations to print:

- Time to be simulated.

- Traffic flows (veh/hr) by direction, vehicle type, and category.

- Desired speeds and maximum entry speeds.

- Vehicle lengths, performance coefficients, and maximum speed on 0% grade.

- Highway characteristics in a position-sequenced, two-way, array.

NOTE: If the highway array generates over 300 lines, the run will be aborted by an illegal operation in Subroutine QUIT.

c. Synopsis: Prints summary of the input data.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: ADJ1, ADJ2, QUIT.

Called by: Main Program (TWOPAS).

f. Formal parameters: None.

g. Common blocks: ADJ, CAR, CV, CW, EXT, GD, INI, PAS, PS, ROA, SMR, SPE, ST, TIM, TOP, TRK, VC, VEH, VEL.

h. Local variables:

Name	Description
CUR1	Mean desired speed (ft/sec) due to horizontal curve or curve approach region in Direction No. 1. Negative for curve or approach to curve to the right. Default value of 202 indicates that the curve has no effect on desired speed.
CUR2	Same as CUR1 for Direction No. 2. A negative value indicates a curve to the right in Direction No. 2.

Name	Description
CWL1	Mean desired downgrade crawl speed (ft/sec) for trucks in a crawl region or approach in the Direction No. 1. Default value of 201 indicates no effect of crawl region on desired speeds.
CWL2	Same as CWL1 for Direction No. 2.
DUM	Utility variable.
DUM2	Utility variable.
GRD1	Local grade (%) in Direction No. 1.
GRT1	Local grade rate (%/ft) in Direction No. 1.
IDUM	Utility variable.
IDUM1	Utility variable.
JPAS1	Passing/no-passing zone code for Direction No. 1:

Code	Meaning
-1	No-passing zone.
0	Passing zone in opposing direction to an added passing or climbing lane.
1	Passing zone on a conventional two-lane highway.
2	Added passing or climbing lane with right-lane drop at downstream end.
3	Added passing or climbing lane with left-lane drop at downstream end.

Name	Description
JPAS2	Passing/no-passing zone code for Direction No. 2.
KDUMP	Count of lines printed in highway characteristics array. If the value of KDUMP exceeds 301, OPUT calls QUIT to terminate run.

Name	Description
R	Utility variable.
S	Maximum normally desired speed (ft/sec).
SGT1	Passing sight distance (ft) in the No. 1 direction.
SGT2	Passing sight distance (ft) in the No. 2 direction.
TT	Utility variable.
XBUF	Buffer length at both ends of simulated roadway in TWOWAF. Now undefined in TWOPAS.
I	Index of loop.
J	Index of loop.
K	Index of loop.
Note:	Variables in COMMON are used in OPUT for special purposes. In particular, X(I)=2,11 is used as the Direction No. 1 coordinate where one of the following variables is printed:

I	Variable
2	CWL2
3	CUR2
4	SGT2
5	JPAS2
6	GRD1
7	JPAS1
8	SGT1
9	CUR1
10	CWL1
11	X1

i. Modifications from TWOWAF: OPUT contains minor modifications in coding from the version used in TWOWAF.

j. Error messages: None.

45. Subroutine PACS(KN,LOC,LTR,MO,IQ)

a. Purpose: PACS is called for a vehicle that, at the end of a vehicle review, is in a section with two lanes available in its direction of travel. This routine packs several data items into the normal subscripted variable for state, KS(IP).

b. Approach: All data items are single-digit integers and are packed into KS(IP) as described below under formal parameters.

c. Synopsis: This routine packs data for a vehicle in an added passing or climbing lane section into the subscripted state variable.

d. Assumptions: None.

e. Relationship to other routines:

Calls: None.

Called by: CLEN2, ZERO2.

f. Formal parameters:

Name	Description
KN	The new state of the vehicle in process at the end of the current review. Supplied by calling routine. Packed in thousands place of KS(IP).
LOC	Lane occupied by vehicle in process: 1 = left lane, 2 = right lane. Supplied by calling routine. Packed in hundreds place of KS(IP).
LTR	Target lane of vehicle in process: 1 = left lane, 2 = right lane. Supplied by calling routine. Packed in tens place of KS(IP).
MO	Motivation for lane change sought by vehicle in process, provided that LTR ≠ LOC. MO is in the range from 0 to 9. Supplied by calling routine. Packed in units place of KS(IP).
IQ	Data subscript for vehicle in process, normally equal to IP. Supplied by calling routine.

g. Common blocks: VEH.

h. Local variables: None.

i. Modifications from TWOWAF: None, new subroutine in TWOPAS.

j. Error messages: None.

46. Subroutine PAGE1

a. Purpose: To process and print data on page 1 of final output. The data printed are:

One-line heading;

Minutes of test time analyzed;

Directional flow rates at finish lines;

Operating speed data; and

The following space data by direction and vehicle type -- vehicle miles, average speed, and measured and specified flow rates.

b. Approach: Accumulated sums and counts assembled during the simulation run are processed and printed in a series of loops. Equivalenced single and double scripted variables are employed for processing and printing convenience.

c. Synopsis: Prints flow rates and operating speeds.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: XBSIG, Z, ZN.

Called by: FPUT2.

f. Formal parameters: None.

g. Common blocks: Blank, PCT, ROA, SCR, SMR, SPE, TIM, UND, VEL.

h. Local variables:

Name	Description
DUM	Total flow rate for both directions from space data.

Name	Description
FB(I,J)	Specified and measured flow rates; I represents the direction of travel; J represents the type and category sequence permitted.
FD1	Finish line flow rate (veh/hr), Direction No. 1.
FD2	Finish line flow rate (veh/hr), Direction No. 2.
FD3	Finish line flow rate (veh/hr), No. 1 and No. 2 direction combined.
IC	Subscript for combined vehicle category and direction of travel: trucks, RVs, and passenger cars are represented by Values 1 through 3 in Direction No. 1 and by 4 through 6 in Direction No. 2.
ICH	Test value for completion of processing vehicle types in a category.
IFB	Subscript for vehicle type-category print sequence: 1-4 represents individual truck types; 5 represents all trucks; 6-9 represents individual RV types; 10 represents all RVs; etc.
IS	Incremented integer for category advance.
IVCAT	Same as IC.
IX	Vehicle type in loop.
JC	Subscript for Directions 1 and 2, and both directions combined (= 3) in operating speed processing.
JJ	Loop limit in operating speed processing.
JL	Loop limit in operating speed processing.
JM	Utility variable.
KQ	Variable in calculation of vehicle type for print.
KWR	Vehicle type in print statement.
OSPH(I,J)	Labels for operating speed print statements.

i. Modifications from TWOWAF: None.

j. Error messages: None.

47. Subroutine PAGE2

a. Purpose: Process and print data on sample size, desired speeds, reference speeds, overall speeds separately for each direction by vehicle type, vehicle category, and all vehicles combined.

b. Approach: Uses accumulated sums and counts from simulation run to assemble line-by-line prints, where each line pertains to a specific combination of direction travel and vehicle type, or vehicle category, or all vehicles combined.

c. Synopsis: Prints sample sizes (samples consist of all vehicles traversing test section and crossing finish line during test time), measured desired speeds, reference speeds, and overall speed statistics.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: XBSIG, Z.

Called by: FPUT.

f. Formal parameters: None.

g. Common blocks: Blank, PAG, PCT, ROA, SCR, SMR, SPE, TIM, UND, VEL.

h. Local variables:

Name	Description
DNSPVT	FNSPVT processed to guard against use as zero divisor.
FNSP	Value of NSP(IC) for vehicle category and direction of travel being processed.
FNSPVT	Number of overall speeds in vehicle type and direction of travel being processed.
IC	Combined subscript for vehicle category and direction of travel.

Name	Description
ICH	Test value for completion of vehicle category processing.
ID	Direction of travel.
IDOUG	Index of loop.
IS	Variable incremented for category in combined subscript for vehicle category and direction of travel.
ISTR	Subscript in range from 1 to 7 for seven representative desired speeds.
IX	Vehicle type in range from 1 to 13.
JM	Utility variable.
JU	Dummy variable.
KVCAT	Vehicle category.
KVT	Vehicle type.
NU	Length of dashed line.
TFRC	Fraction of specified flow for direction of travel and vehicle type being processed.
TSADSC	Specified, bias-adjusted, mean desired speed (ft/sec) for category being processed.
DNSP	FNSP processed to guard against use as zero divisor.
I	Combined subscript for vehicle type and direction of travel.

Note: DSIGT(I) is used locally for reference speed for vehicle type and direction of travel I.

i. Modifications from TWOWAF: None.

j. Error messages: None.

48. Subroutine PAGE3

a. Purpose: Process and print data on sample sizes, reference travel times and delays (sec/mile), and measured travel times and delays (sec/mile). Results are printed by direction of travel, vehicle type, vehicle category, and for all categories combined.

b. Approach: Uses accumulated sums and counts from simulation run to assemble line-by-line prints where each line pertains to a particular direction of travel, vehicle type, vehicle category, or all vehicles combined.

c. Synopsis: Prints sample sizes, travel times, and delays (sec/mile).

d. Assumptions: Note that the base for delay in each vehicle type is a reference rate (sec/mile) achieved by the isolated vehicle on ideal (straight and level) alignment. If the vehicle is performance limited on the ideal alignment, its reference rate (sec/mile) will be larger than desired. However, this penalty, arising in the ideal conditions, is not included in the geometric, traffic, or total delay. The performance penalty under ideal conditions can be seen by examining the reference rate (sec/miles).

e. Relationship to other subroutines:

Calls: XBSIG, Z.

Called by: FPUT2.

f. Formal parameters: None.

g. Common blocks: Blank, PAG, PCT, ROA, SCR, SMR, SPE, UND, VEL.

h. Local variables:

Name	Description
DD	Sum of overall travel times for direction of travel being processed.
DNSP	FNSP processed to guard against use as zero divisor. Not used.
DUM	Bias of desired speeds for vehicle category being processed.
FNSP	NSP(IC) for vehicle category and direction of travel processed.

Name	Description
FNSPVT	Number of overall speed measurements for type-direction in process. (NSPVT(IP)).
IC	Combined subscript for vehicle category and direction of travel.
ICH	Test value for completion of vehicle category processing.
ID	Direction of travel.
IDOUG	Index of loop.
IS	Variable incremented for vehicle category in determining value of IC.
ISTR	Subscript in range from 1 to 7 for seven representative desired speeds.
IX	Vehicle type, in range from 1 to 13.
JM	Utility variable.
JU	Dummy variable.
KVCAT	Vehicle category.
KVT	Vehicle type.
NU	Dashed line range.
I	Combined subscript for direction of travel and vehicle type.

i. Modifications from TWOWAF: None.

j. Error messages: None.

49. Subroutine PAGE4

a. Purpose: Process and print overall speed histograms by direction of travel and for both directions combined, by vehicle category and all categories combined; with number, percent, and cumulative percent for each. (The printed data occupies two printed pages.)

b. Approach: Counts by vehicle category and speed stratum are divided by counts over all speed strata to obtain strata percent. Factors set equal to either zero or one are used to assemble directional and combined data.

c. Synopsis: Prints two pages of overall speed histograms.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: Z, ZN.

Called by: FPUT2.

f. Formal parameters: None.

g. Common blocks: Blank, PCT, SCR, SMR, TOP, UND.

h. Local variables:

Name	Description
ID	Index of loop; also employed in calculating directional factors.
JD	Index of loop.
JF	Index of loop.
JU	Dummy variable.
J1	Lower bound on speed stratum (ft/sec).
J2	Upper bound on speed stratum (ft/sec).
K4	Page number.
NU	Length of dashed line.
JJ	Factor for assembly of Direction No. 1 data by direction of travel and for both directions combined.
JL	Factor for assembly of Direction No. 2 data by direction of travel and for both directions combined.

i. Modifications from TWOWAF: None.

j. Error messages: None.

50. Subroutine PAGE5

a. Purpose: Process and print histograms of time margins (sec) in passes, pass aborts, and passes and pass aborts combined. Data are printed by direction of travel and for both directions combined with number, percent, and cumulative percent.

b. Approach: Factors equal to 100/counts are formed first. Percents are formed and printed in a second major loop over directions of travel and both directions combined. Directional factors (0 or 1) are used in the second major loop.

c. Synopsis: Prints time margin histograms for passes and aborts.

d. Assumptions: The time margins in passes include passes in which no oncoming vehicle is in sight and the margin is based on time to end of pass zone if it is in sight. Otherwise, the margin is time to reach end of current passing sight distance.

The time margins in aborts are the projected pass margins when the abort was initiated.

e. Relationship to other subroutines:

Calls: ZN.

Called by: FPUT2.

f. Formal parameters: None.

g. Common blocks: Blank, PCT, SCR.

h. Local variables:

Name	Description
JD	Indicator for direction of travel or for both directions combined: 1 = No. 1 Direction; 2 = No. 2 Direction; and, 3 = both directions combined.
JF	Index of loop.
J1	Lower bound of time margin stratum.
J2	Utility variable; final use as upper bound of time margin stratum.
J3	Utility variable.

Name	Description
M1	Factor for No. 1 Direction.
M2	Factor for No. 2 Direction.
K	Index of loop.

i. Modifications from TWOWAF: None.

j. Error messages: None.

51. Subroutine PAGE6

a. Purpose: Process and print data on frequencies of passes and pass aborts, on platoon leaders, and on percent of time vehicles are unimpeded.

b. Approach: Accumulated sums and counts assembled during the simulation run are processed and printed.

c. Synopsis: Prints data on passes, pass aborts, platoon leaders, and percent of time vehicles are unimpeded.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: Z, ZN.

Called by: FPUT2.

f. Formal parameters: None.

g. Common blocks: Blank, PCT, ROA, SCR, SMR, UND.

h. Local variables:

Name	Description
DI	Local variable for VMD(JD) in direction processed, and guarded against zero.
DUM	Multiplier to convert event counts to events/(lane-mile-hour).
DV	Vehicle-miles, guarded against zero.
IS	Vehicle category.

Name	Description
JU	Dummy variable.
M1	Factor for Direction No. 1.
M2	Factor for Direction No. 2.
NU	Length of dashed line.

i. Modifications from TWOWAF: None.

j. Error messages: None.

52. Subroutine PAGE7

a. Purpose: Processes and prints time headway histograms at start and finish lines by direction of travel and for both directions combined. Also, processes and prints histograms of platoon sizes at finish lines by direction of travel and for both directions combined. Free vehicles (platoons of one vehicle) are included for completeness; such vehicles are not considered to be platoon leaders or platoons in other output.

b. Approach: Factors for calculations of percentages are formed as DIV(J). Calls are made to PRGRPH(JHD,L) for final processing and printing.

c. Synopsis: Printing of headway and platoon.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: PRGRPH, ZN.

Called by: FPUT2.

f. Formal parameters: None.

g. Common blocks: Blank, PCT, SCR.

h. Local variables:

Name	Description
HSBS(I)	Heading data.

i. Modifications from TWOWAF: None.

j. Error messages: None.

53. Subroutine PAGE89(NPL,KD)

a. Purpose: Process and print data on overtaking events by direction of travel and for both directions combined, by number of vehicles in overtaking platoon, by initial speed difference, and initial acceleration response. This routine also prints overtaking event rates and acceleration noise data.

b. Approach: Data on overtaking are accumulated during the simulation run and are printed by looping over direction of travel, platoon size, and event severity. Overtaking rates are assembled from overall counts. Acceleration noise is calculated from accumulated speed change data.

c. Synopsis: Prints data on overtaking events and acceleration noise.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: XBSIG, Z.

Called by: FPUT2.

f. Formal parameters:

Name	Description
NPL	Code for variable to be processed.
KD	Page number (8 or 9); also used as a control code.

g. Common blocks: Blank, PCT, ROA, SCR, SMR, TIM.

h. Local variables:

Name	Description
FAC(I)	Heading data.
FDL	Variable in calculation of stratum bounds.
FMP	Variable in calculation of stratum bounds.
FMX	Variable in calculation of stratum bounds.
F1	Stratum bound for overtaking; also, directional factor in Direction No. 1.
F2	Strata bound for overtaking; also, directional factor in Direction No. 2.
HED89(I)	Headings.
J1	Stratum bound.
J2	Stratum bound.
K1	Variable in calculation of stratum bounds.
K2	Variable in calculation of stratum bounds.
K6	Limit of loop.
LANE	Alphanumeric data for heading.
M1	Direction factor for No. 1 Direction.
M2	Direction factor for No. 7 Direction.
ROAD	Alphanumeric data for heading.
TNPL(I)	Cumulative event counts for rate calculations.
VLM	Sum of speed changes.
VSM	Sum of speed changes squared.

i. Modifications from TWOWAF: None.

j. Error messages: None.

54. Subroutine PASP

a. Purpose: Calculates pass acceptance probability, given defined circumstances, based on constraints on passing, impeder's speed, position of potential passer in platoon, horizontal curvature, and effect of recent entry into passing zone.

b. Approach: A branch on the variable ITYPE separates cases with oncomer in sight (ITYPE=3) from oncomer not in sight. The subscript of coefficients to be used are selected from either passing sight distances or passing opportunity distances rounded to the nearest 100 ft. The impeder's speed with respect to the appropriate reference speed is used to select speed sensitivity coefficients. The pass acceptance probability is calculated as a distance-related part plus a part proportional to leader speed minus reference speed. Factors for horizontal curvature and for position in platoon are employed in the probability calculation.

c. Synopsis: Determines PP, the probability of accepting a defined passing opportunity, as a fraction in the range from 0 to 1.0.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: ST14.

f. Formal parameters: None.

g. Common blocks: CAR, PAS, PPT, VIC.

h. Local variables:

Name	Description
DUM	Speed difference. (Impeding vehicle speed) - (reference speed).
FS(IDS)	Factor for pass acceptance enhancement due recent entry to pass zone (a function of sight distance).
FSUBS	Nonsubscripted symbol for FS(IDS).
IDO	Subscript of coefficients to be applied; based on passing opportunity distance, POD.

Name	Description
IDS	Subscript of coefficients to be applied; based on local passing sight distance, SGT.
O	Nonsubscripted symbol for coefficient of speed difference DUM.
P41(IDS)	Array of coefficients determined as a function of sight distance.
P44(IDO)	Array of coefficients determined as a function of passing opportunity distance.
SON(IDO)	Array of coefficients, used when impeder speed $\leqq$ 44 ft/sec; oncoming vehicle constraint.
SOP(IDO)	Array of coefficients, used when impeder speed > 44 ft/sec; oncoming vehicle constraint.
SSN(IDS)	Array of coefficients, used when impeder speed $\leqq$ 41 ft/sec; sight distance constraint.
SSP(IDS)	Array of coefficients, used when impeder speed > 41 ft/sec; sight distance constraint.

i. Modifications from TWOWAF: None.

j. Error messages: None.

55. Subroutine PASZ2(XP)

a. Purpose: This routine determines if position XP, direction JD, is in a passing zone, a no-passing zone, or an added passing or climbing lane. The routine determines a value of JPAS, which is equal to 1 for a passing zone; -1 for a no-passing zone; 2 for added passing or climbing lane with a right lane drop; and 3 for added passing or climbing lane with left lane drop. If JPAS is equal to -1, the routine determines the value of PASE which represents the downstream end of the passing zone most recently exited.

b. Approach: PASZ2 begins its search for the correct value of JPAS with the passing zone region subscript set equal to LP. The routine searches zones incrementally (LP ± 1) using position difference tests against XP. The routine recognizes NLP(JD) and MLP(JD) as furthest upstream and downstream passing zone regions for direction JD.

c. Synopsis: For position XP in direction JD, the routine determines the type of passing zone and the location of the end of the current no-passing zone or added lane.

d. Assumptions: The starting point (LP) is subscript of zone located on the previous call to PASZ2. This is initialized as MLP(JD), i.e., the furthest downstream zone, when processing begins for each direction of travel.

e. Relationship to other subroutines:

Calls: None.

Called by: ALN, ST14, ST5.

f. Formal parameters:

Name	Description
XP	Directional position (ft) for which passing zone information is to be obtained. Supplied by calling routine.

g. Common blocks: CAR, PAS, PS, ROA.

h. Local variables:

Name	Description
IDUM	Equal to LP+1, where LP is the subscript of region interrogated.

i. Modifications from TWOWAF: PASZ2 replaces Subroutine PASZ used in TWOWAF.

j. Error messages: None.

56. Subroutine PLNC(LFV,JSTAT,JSZ,ITCR,VFR,LHCZ)

a. Purpose: PLNC manages the initial lane choice by vehicles entering an added passing or climbing lane. PLNC is called at the end of a vehicle review when the vehicle in process is found to have entered a section with an added passing or climbing lane. PLNC calculates the probability that the vehicle will enter right lane and, if necessary, uses a random number in a stochastic test to determine the lane selected. The lane selected for the vehicle in process is returned as LHCZ.

b. Approach: PLNC uses the information supplied by formal parameters to assemble equation coefficients and table values that determine probability of choosing the right lane. The probability may be greater than or equal to 1.0, in which case the right lane is always selected. Otherwise, the final decision is made stochastically.

c. Synopsis: PLNC determines the initial lane choise for a vehicle entering an added passing or climbing lane.

d. Assumptions: Tables and coefficients are based on field data collected in moderately graded alignments by Harwood and St. John,[10] supplemented by data collected in low flows at climbing lanes on steeper grades by the University of California-Berkeley[3] and by experience with multilane data in level and graded alignments. The initial lane choices should be appropriate for passing lanes in level or rolling terrain, and for climbing lanes with low flow rates. The choices may also be appropriate for climbing lanes with high flow rates, but this has not been verified from field data.

e. Relationship to other subroutines:

Calls: RAN(4).

Called by: CLEN2.

f. Formal parameters:

Name	Description
LFV	Code for entry favored by local geometrics and traffic control: 1 = left lane preferred; 2 = no lane preference; 3 = right lane preferred. Supplied by calling routine.
JSTAT	Code for status of entering vehicle: 1 = free vehicle; 2 = platoon leader; 3 = platoon member. Supplied by calling routine.
JSZ	Code for vehicle size: 1 = large vehicle; 2 = small vehicle. As implemented here, trucks and the two lowest performance RVs are large vehicles; the two highest performance RVs and all passenger cars and light trucks are small vehicles. Supplied by calling routine.
ITCR	Code for stratum of seconds to catch up with vehicle ahead in right lane. Supplied by calling routine.

Name	Description
VFR	Speed increase above platoon leader in 2 sec if vehicle in process were free. Supplied by calling routine.
LHCZ	Code for lane selected: 1 = left lane, 2 = right lane. Returned to calling routine.

g. Common blocks: CHOZL, CAR, ROA, SPE.

h. Local variables:

Name	Description
CSO	Utility variable.
CS1	Utility variable.
FSPD	Utility variable.
PR	Probability of selecting right lane.
RAND	Random number (in range from 0 to 1.0) returned by RAN(4).

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

57. Subroutine POUT(JTAB,NLA)

a. Purpose: POUT is called after the simulation run, during final output. At each call, POUT processes and prints the spot data that had been collected during the simulation run at one of the user-specified data collection stations.

b. Approach: The arrays used to assemble and print data are first cleared. The program logic branches on NLA, number of lanes available in the appropriate direction of travel at station JTAB, to separate processing for one and two lane sections. The logic paths rejoin at statement 400 to print results. The direction of travel (1 or 2) is determined from JTAB, since values of from 1 to 20 are reserved for Direction No. 1 and values from 21 to 40 are reserved for Direction No. 2. The headings and overall format are the same for NLA = 1 and = 2. If only one lane is available at the station in question, the single lane data are printed under the "combined" or "both" headings.

c. Synopsis: Processes and prints data from one user-specified data collection station.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: FPUT2.

f. Formal parameters:

Name	Description
JTAB	Single subscript for spot data stations. JTAB ranges from 1 to 20 in Direction No. 1 and from 21 to 40 in Direction No. 2. Supplied by calling routine.
NLA	Number of directional lanes available in appropriate direction of travel at station JTAB. Supplied by calling routine.

g. Common blocks: SPOT, STAT, TIM.

h. Local variables:

Name	Description
I	Index of loop.
IL	Generic lane number: 1 = left lane, 2 = right lane. (Applicable only when NLA = 2.)
ILI	Subscript for IOP, representing column in which data are to be printed.
ILS	Subscript for XOS, representing column in which data are to be printed.
ILX	Subscript for XOP, representing column in which data are to be printed.
IOP(K,ILI)	Integer counts in printed platoon data. K represents vehicle category: 1 = trucks, 2 = RVs, 3 = passenger cars, and 4 = combined; ILI represents column position in print array.

Name	Description
ISTA	Directional station number. Equals JTAB for Direction No. 1; equals JTAB-20 for Direction No. 2.
J	Index of loop.
JD	Direction of travel.
LB1(4)	Line headings; defined in a data statement.
LB2(4)	Line headings; defined in a data statement.

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

58. Subroutine PRGRPH(JHD,L)

a. Purpose: Assembles and prints headway and platoon histograms after headings are printed and normalizing factors are assembled by the calling program, PAGE7.

b. Approach: Assembles counts accumulated during the simulation run, applies normalizing factors for percentages, and prints results using line identifiers defined in the processed data.

c. Synopsis: Prints headway and platoon data.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: PAGE7.

f. Formal parameters:

Name	Description
JHD	Code for variable to be processed.
L	Subscript of range to be employed.

g. Common blocks: SCR.

h. Local variables:

Name	Description
B	Single blank space.
BLANK	Data defined single blank space.
GT	Label for printing GT.
JP	Subscript for normalizing factor.
KB	Do loop range and variable in subscript calculations.
KD	Locally defined data used to set do loop ranges.
KP	Locally defined data used to set do loop ranges.
ND(I)	Array defined with data.
NHHDWY(I)	Array defined with data, for line definitions.
NK(I)	Array defined with data.

i. Modifications from TWOWAF: None.

j. Error messages: None.

59. Subroutine PRIM2

a. Purpose: PRIM2 manages the placement of vehicles on the roadway prior to the beginning of simulation processing (i.e., "priming" of the simulated roadway). PRIM2 places the dummy vehicles (subscripts 1 through 8) beyond the ends of simulated roadway. The routine initializes data for calls to ZERO2, where zero-traffic speeds are calculated for each combination of vehicle type and direction of travel using seven representative desired speeds. In processing the fourth representative speed (i.e., the mean desired speed) in ZERO2, the simulated roadway is primed by placing initial vehicles along its length. PRIM2 also processes the zero traffic results and prints overall travel times (sec/mile) and speeds (ft/sec) together with data on the representative speeds.

b. Approach: Dummy vehicles are assigned pointers LD(JJ) and LJ(JJ) in preparation for inserting priming vehicles using standard pointer logic. PRIM2 tests for zero flow rate specifications are made during processing for zero traffic speeds and times and initializes related reference values. Reference times and speeds are printed.

c. Synopsis: PRIM2 sets the eight dummy vehicles and manages the calculation of zero traffic reference times and speeds during which the priming is done by ZERO2. PRIM2 also prints zero traffic reference values.

d. Assumptions: None. CAUTION: JVT is used here as non-subscripted local variable. During simulation processing, it is a subscripted variable in COMMON/REG/. This COMMON must not be added to this routine.

Vehicles may be primed very close together or very close to the end of the left lane in a type 3 passing or climbing lane. It is assumed that standard logic will resolve these critical situations in the first few seconds of simulated time prior to the end of the warmup periods. Error messages in the first few seconds of the simulation run are occasionally generated by closely spaced primed vehicles and these error messages should be ignored.

e. Relationship to other subroutines:

Calls: ZERO2.

Called by: Main Program (TWOPAS).

f. Formal parameters: None.

g. Common blocks: CAR, CV, CW, GD, GEO, INI, I7SPD, PS, ROA, SMR, SPE, TIM, TOP, VEH, VEL, ZER.

h. Local variables:

Name	Description
C50	Upstream dummy locations (set equal to -50 in a data statement).
J	Index of loop.
JDUM1	Lower bound for JVT in direction JD.
JDUM2	Upper bound for JVT in direction JD.
JJ	Subscripts for the eight dummy vehicles (in range from 1 to 8).
JVT	Combined subscript for vehicle type and direction of travel: in range from 1 to 13 for JD = 1; in range from 14 to 26 for JD = 2. See CAUTION under assumptions.

Name	Description
JV1	Lower bound for JVT.
JV2	Upper bound for JVT.
K	Index of loop.
KAT	Vehicle category: 1 = truck; 2 = RV; 3 = passenger car.

i. Modifications from TWOWAF: PRIM2 replaces Subroutine PRIME in TWOWAF. Eight dummy vehicles are listed in place of the four used in TWOWAF. The additional dummy vehicles are needed to provide for the possibility of an added lane in either direction of travel.

j. Error messages: None.

60. Subroutine PROCI

a. Purpose: Input data is manipulated and processed by PROCI.

b. Approach: Pointers are initiated in PROCI for both the regular and extra data subscripts in preparation for priming and simulation. Packed data for the vehicles in entering traffic streams are assembled by a call to ENQUE. Regions for grades, curves, sight distances, passing/no-passing, and downgrade crawl are processed individually, first in Direction No. 1 then in Direction No. 2. PROCI makes temporary use of subscripted variables normally employed for other purposes in simulation processing.

Driver work load coefficients are set equal to zero in PROCI to disable this feature. The seven speeds representative of the desired speed distribution are calculated. The number of lanes available at each specified data station is determined by calls to PASZ2 and the results are stored in the NLANS array.

c. Synopsis: Preparation of program data by PROCI includes calculation of approach regions, curve speeds, and the insertion of nominal values for unspecified road regions. The maximum speed on zero grade is calculated for each vehicle type. The speed on ideal alignment is determined for each vehicle type and data for the entering traffic streams are assembled by a call to ENQUE.

d. Assumptions: None.

e. Relationship to other subroutine:

Calls: ENQUE, PASZ2, QUIT.

Called by: Main Program (TWOPAS).

f. Formal parameters: None.

g. Common blocks: Blank, BKPM, CV, CW, DIM, EPR, EXT, FHP, GD, GEN, INI, NLANS, SVSIZ, PAS, PE, PS, ROA, SMR, SPE, ST, STAT, TIM, TRK, VC, VEH, VEL, ZPASPL, XCOUNT, XHEAD, XHMAX, ZK.

h. Local variables:

Name	Description
AP	Acceleration performance of truck on zero grade at speed XD.
DTR	Conversion factor, degrees to radians.
DUM	Utility variable.
DUM1	Utility variable.
DUM2	Utility variable.
IDUM	Utility variable.
IDUM1	Utility variable.
IDUM2	Utility variable.
IHCV	One-half the dimension for horizontal curve arrays.
ILAST	Last subscript assigned; incremented as regions are assigned.
ISTR	Subscripts of representative desired speeds and basic variance variable.
JTAB	Subscript for NLANS in linear array covering both directions.
JW	Passing zone subscript. (Assigned but inactive.)
J1	Minimum subscript of passing zones to be processed in input.

Name	Description
J2	Maximum subscript of passing zones to be processed in input.
KVT	Vehicle type.
K1	Utility variable, usually minimum subscript to be processed.
K2	Utility variable, usually maximum subscript to be processed.
MX	Temporary storage for maximum station subscript in direction processed.
T	Entering time headways in calculations of probability tables.
XD	Truck speed (ft/sec).
XLAST	Downstream location of region last assigned during processing.

i. Modifications from TWOWAF: The entering traffic streams, previously determined in PROCI, are now assembled by a call to ENQUE. Workload coefficients are now zeroed. The number of lanes available at each user-specified station are now determined and stored in PROCI.

j. Error messages: Three error messages can be printed. Each indicates that input data will overflow the dimensional limits for a roadway feature. In each case, the program branches to a call to QUIT which will produce an abnormal exit. The messages and data printed are:

CURVE DATA OVERFLOW
XCVN(J), CVO(J), CV1(J), CV2(J), RCV(J), J = 1, IHCV
where IHCV = ZV/2

CRAWL DATA OVERFLOW
XCWN(J), CWO(J), CW1(J), CW2(J), RCW(J), J = 1, ZW

SIGHT DATA OVERFLOW
XSGO(J), SGTO(J), RST(J), J = 1, ZT

61. Subroutine PTAID

a. Purpose: PTAID calculates the passing time (sec) available as part of the initial decision to pass.

b. Approach: The estimate of the passing time available is based on distance to the opportunity limiting feature, closure speed, and acceleration, if any, of impeder.

c. Synopsis: Calculates the passing time available.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: QUAD1.

Called by: ST14.

f. Formal parameters: None.

g. Common blocks: CAR, PAS, QUA, ROA, TIM, VC, VEH, VIC.

h. Local variables:

Name	Description
DIS	Initially, position of opportunity limit; ultimately the distance to limiting feature (ft).
VCLOS	Speed of closure (ft/sec) including oncomer speed, if appropriate.

i. Modifications from TWOWAF: None.

62. Subroutine PTRID

a. Purpose: PTRID calculates the passing time (sec) required as part of the initial decision to pass.

b. Approach: PTRID employs equations based on a larger number of analytically calculated passing maneuvers. Branches are made to select the appropriate logic. The initial branch is between trucks or RVs and passenger cars. Subsequent branches distinguish differences in the gain to be achieved over impeder, and cases in which the impeding vehicle's acceleration will be $\leqq$ zero or $>$ zero, and cases in which a preferred limit speed is or is not reached during the pass.

All calculations assume that the time to pass is the time to clear impeder plus 2 sec.

c. Synopsis: PTRID calculates projected time required to pass.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: QUAD1.

Called by: ST14, ST5.

f. Formal parameters: None.

g. Common blocks: CAR, GEO, QUA, STA, VC, VEH, VIC, ZER.

h. Local variables:

Name	Description
BETA	An inverse function of maximum performance acceleration of potential passer for RVs and passenger cars.
BZ	Coefficient in equations for time to clear or time to pass.
DUM	Ratio of (speed increase to limit speed)/(speed increase in pass).
GAM	An inverse function of maximum performance acceleration of potential passer (truck).
TADD	Time required to clear impeder - time to reach limit speed (sec).
TC	Elapsed time (sec) to clear impeding vehicle; truck projecting pass.
TMP	Elapsed time (sec) when potential passer reaches limit speed.
VIM	Impeder's speed (ft/sec) at time TMP when passer reaches limit speed.

i. Modifications from TWOWAF: None.

j. Error messages: None.

63. Subroutine QUAD1

a. Purpose: QUAD1 calculates the smallest real positive solution of a quadratic equation or, if there is no real positive solution, QUAD1 return an acceptably large answer of 1001 or 1002.

b. Approach: The routine provides tests and solutions for all possible cases of the quadratic equation.

c. Synopsis: This subroutine provides solutions to quadratic equations.

d. Assumptions: Input in COMMON is BZ2 corresponding to B/2 and CZ corresponding to C in the form T**2 + B*T + C = 0.

e. Relationship to other subroutines:

Calls: None.

Called by: PTAID, PTRID, ST5.

f. Formal parameters: None.

g. Common blocks: QUA.

h. Local variables:

Name	Description
ANZ1	Solution with positive square root of discriminant.
ANZ2	Solution with negative square root of discriminant.
DUMZ	Discriminant or its square root.

i. Modifications from TWOWAF: None.

j. Error messages: None.

64. Subroutine QUIT

a. Purpose: QUIT triggers an abnormal exit by supplying an out-of-range integer for a computed GOTO statement. (Note: Through JCL, the user can specify dump in event of abnormal exit.)

b. Approach: See purpose.

c. Synopsis: Triggers an abnormal exit.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: OPUT, PROCI.

f. Formal parameters: None.

g. Common blocks: None.

h. Local variables:

Name	Description
J	GO TO statement argument.

i. Modifications from TWOWAF: None.

j. Error messages: None.

65. Function RAN(N)

a. Purpose: Provide five random number sequences, each with random numbers in the range from 0 to 1.0. The uses of these random number sequences are described below:

N	Application
1	Direction No. 1 entering headways and vehicle types.
2	Direction No. 2 entering headways and vehicle types.
3	Direction No. 1 desired speeds during simulation.
4	Desired speeds for priming vehicles, and then, without reset, pass acceptances during simulation.
5	Direction 2 desired speeds during simulation.

b. Approach: Each random number is calculated by scaling the remainder from a quotient where the numerator is the product of the previous unscaled random number and 262147 and the denominator is 34359738368.

The initial, unscaled random numbers, or seeds, can be supplied in input; otherwise, default values from block data are employed.

c. Synopsis: Calculates five random number sequences, distinguished by the integer argument in the call.

d. Assumptions: Cycle length to replication or duplication will not be a problem.

e. Relationship to other subroutines:

Calls: None.

Called by: ST14, ST5, VASGN, VGEN.

f. Formal parameters:

Name	Description
N	See purpose.

g. Common blocks: RNS.

h. Local variables:

Name	Description
NUM	Utility variable.
RN	Unscaled random number.

i. Modifications from TWOWAF: None.

j. Error messages: None.

66. Subroutine REED2

a. Purpose: REED2 reads and stores all of the input data supplied by the user. REED2 also provides an expanded format printout of each input card that is read. This routine also provides a branch (through negative integer in Columns 1 through 4) to process extra output data (stored on Unit 4) during a simulation run just completed. (Note: Transfers to Unit 4 in SAVERF and COMMONs read from Unit 4 in Subroutine EXOUTP have not been updated for data on added passing and climbing lane sections.)

Subroutine REED2 also writes part of input data to a file on Unit 10 which may be used in processing fuel consumption data.

b. Approach: REED2 detects last comment card by blank field in Columns 1 through 4. The routine then reads 10 mandatory cards directly to appropriate variables. Then optional cards (all in same format) are read to temporary variables; the card type is determined by REED2 from the letter in Column 2 and control is transferred to the appropriate statements to interpret the data. (Note that each optional card contains sufficient information to permit correct subscripting of the data.) REED2 interprets a blank card as the end of data. REED2 prints each card immediately after reading it, except for card with negative integer in Columns 1 through 4. The details of input and output formats are presented in the TWOPAS User's Manual.[1]

c. Synopsis: Cards are read and immediately printed. Their processing order is: comment cards first, mandatory data cards second, optional cards third.

d. Assumptions: At least two comment cards are required; the last comment card must have a blank field in Columns 1 through 4. Ten data cards must follow -- in mandatory Sequence 1 through 10. At least two optional SL cards are required in each direction of travel.

e. Relationship to other subroutines:

Calls: EXIT, EXOUTP.

Called by: Main Program (TWOPAS).

f. Formal parameters: None.

g. Common blocks: BKPM, CMTOUT, CV, CW, EPR, FHP, FUL, GD, OO, PAS, PS, RNS, ROA, SMR, SPE, ST, STAT, SWT, TIM, TOP, TRK, UPE, VC, VEH, VEL, XPPL, ZKCOR.

h. Local variables:

Name	Description
BUF(I)	Array containing last 60 positions of optional data card.
FUEL = IFUEL	Control for collection of fuel consumption data.
I	Utility variable and index of loop.
IGEOM	Code for geometrics in data set. Stored in fuel consumption file but not used in computations.

Name	Description
II	Index of loop.
IMODEL	Code for this two-lane two-way model. Not used in computations.
IO	Index of loop.
IPOPTP	Code for type vehicle characteristics projection. Stored in fuel consumption file but not used in computations.
IPOPYR	Code for projected year of vehicle population. Stored in fuel consumption file but not used in computations.
IREPLT	Code for replicate number. Stored in fuel consumption file but not used in computations.
ISFLO	Code for estimated v/c ratio. Stored in fuel consumption file but not used in computations.
ISPLIT	Code for specified directional split. Stored in fuel consumption file but not used in computations.
ISTA	User-specified data collection station sequence number in direction JDD.
IVMIX	Code for specified distribution of vehicle types. Stored in fuel consumption file but not used in computations.
J	Index of loop.
JDD	Direction of travel, 1 or 2.
JDUM	Second subscript of upstream speed table.
JJ	First integer in optional card inputs (except data stations).
JK	Direction of travel in data specified for upstream speeds.
JKK	Index of loop over an upstream speed table.
K	Fourth integer in optional card inputs (except data stations).

Name	Description
KK	Integer used to read alphanumeric data in Column 2 on optional cards.
KO	Code. Equal 0 initially; equal 1 after first comment card is read. Provides extra test on first card.
KVT	Vehicle type in range from 1 to 13, in vehicle mix data and maximum entry speed data.
KX	First alphanumeric on optional data cards (except station data).
M	Do loop index.
MX	Temporary storage for maximum data station number in direction processed.
M1,M2	Second and third integer numbers on optional cards (except station data).
TEMP(M)	Individual driver type following characteristic factors, M = 1,10.
XBUF	No longer used in TWOPAS.
XMS1	Real number form of maximum data station in Direction No. 1.
XMS2	Real number form of maximum data station in Direction No. 2.

i. Modifications from TWOWAF: Several input data items have been added in TWOPAS. The data on 10 driver types were added by KLD in NCHRP Project 3-28A. New input data also include: a code to specify upstream alignment for use in entering platoon formations; user-specified stations for spot data collection; user-specified subsections for space/section data collection; and the variables for passing zone types have been expanded to encompass added passing and climbing lane sections with a user-specified bias for lane preference at the lane addition.

j. Error messages:

Message	Interpretation
ERROR-CAR FOLLOWING SENSITIVITY FACTOR NOT INPUT	Card with I, ZKCOR, TEMP(M), M = 1,10 not supplied, or, I not equal 10, or ZKCOR ≦ 0.0. Routine calls EXIT after print. Note that the TEMP need not be supplied, in which case program will use BLOCK DATA values.

67. Subroutine SAVERF

a. Purpose: SAVERF summarizes data collected up to current simulation time and write to an intermediate on Unit 4.

b. Approach: Several COMMONs, in single array form, are written to Unit 4, unformatted. The test time written on this file is the total test time simulated to this point.

c. Synopsis: All current data values are written to an intermediate file for later recall and processing.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: Main Program (TWOPAS).

f. Formal parameters: None.

g. Common blocks: Blank, CAR, PAG, PCT, ROA, SCR, SMR, SPE, TIM, TOP, TRK.

h. Local variables:

Name	Description
S	Used to store specified value of TTES temporarily.
TTES	Simulation time (min) for which data are to be collected during simulation processing.

i. Modifications from TWOWAF: None.

j. Error messages: None.

68. Subroutine SERT(LC,NFOL)

a. Purpose: Following a lane change, SERT is called to reset pointers that place vehicle Number LC in front of vehicle number NFOL.

b. Approach: The vehicle number of NFOL's original leader is held as local variable LOLD while the pointers are reset.

c. Synopsis: Inserts vehicle with data subscript LC in front of vehicle with data subscript NFOL.

d. Assumptions: None.

e. Relationship to other subroutines.

Calls: None.

Called by: CLEN2, LCBOK.

f. Formal parameters:

Name	Description
LC	Subscript of vehicle being inserted.
NFOL	Subscript of vehicle that becomes the new follower of inserted vehicle LC.

g. Common blocks: VEH.

h. Local variables:

Name	Description
LOLD	Subscript of vehicle originally the leader of NFOL.

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

69. Subroutine SETFF(RC,RB,RT)

a. Purpose: Calculate ZFFX(I,J), a set of space gaps (ft) to be used as free-flow distance thresholds: I=1,10;J=1,10, where leader speed = (I-1)*10 ft/sec and follower speed = (J-1)*10.

b. Approach: Equations used to determine ZFFX are based on the KLD-Pitt car following model.

c. Synopsis: Calculates a table of free-flow threshold car-following space gaps.

d. Assumptions: Space gaps calculated are large enough to catch all driver-type vehicle-speed combinations for which a more complete car following equation should be used.

e. Relationship to other subroutines:

Calls: None.

Called by: Main program (TWOPAS).

f. Formal parameters:

Name	Description
RB	Coefficient of term nonlinear in speed. Supplied by calling routine. (Defined as 0.10 in BLOCK DATA.)
RC	Driver response delay (sec). Supplied by calling routine. (Defined as 0.30 sec in BLOCK DATA.)
RT	Simulation time step (sec). Supplied by calling routine.

g. Common blocks: RAMAX, RVMAX, YTRACE, ZFFX, ZK.

h. Local variables:

Name	Description
I	Index of loop.
IK	Integer form of follower speed (ft/sec).
J	Index of loop.
R	Computed value for ZFFX(I,J).
RA	Acceleration capability of follower (ft/sec^2).
RTAU	Time step driver response delay.
RU	Leader speed (ft/sec).
RV	Follower speed (ft/sec).
R1	RTAU*RTAU/2.0.
R2	RB*RTAU.
R3	Term nonlinear in speed.

i. Modifications from TWOWAF: None.

j. Error messages: None, however, YTRACE > 0 will result in printout of ZFFX(10,10).

70. Subroutine SETZK

a. Purpose: Calculates the array ZK(100), a table of factors in the KLD-Pitt car-following model, indexed to the follower speed.

b. Approach: Values of ZK are calculated with the model, nonlinear equation, and then multiplied by ZKCOR. Values are adjusted to an upper bound of ZK(25).

c. Synopsis: See purpose.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: TRACE.

Called by: Main program (TWOPAS).

f. Formal parameters: None.

g. Common blocks: YTRACE, ZK, ZKCOR, ZKF, ZKJ, ZL, ZM, ZUF.

h. Local variables:

Name	Description
I	Index of loop.
RA	ZL-1.0.
RAI	1.0/RA.
RK	ZKJ**RA - ZKF**RA.
RKF	ZKF**RA.
RM	1.0-ZM.
RMP	RSP*60./88.
RSP	Real variable value of I.
RTEMP	Intermediate value in calculation of ZK.

i. Modifications from TWOWAF: None.

j. Error messages: None, however, YTRACE > 0 causes RM, RA, RK, and RKF to be printed by TRACE and also causes printout of ZK(I), I=1,100.

71. Subroutine SGHT

a. Purpose: SGHT finds the passing sight distance (SGT) at location XX for the direction of travel being processed.

b. Approach: The search begins at region subscript LS which is either initialized for a new direction of travel or is the region found in last call to SGHT for the direction of travel in progress. The subscript for the correct region is located by incrementing or decrementing LS as necessary. Then, the sight distance is calculated as linear function of position within the region. SGHT substitutes the specified minimum sight distance (SMIN) if a smaller value is calculated.

c. Synopsis: Determines the passing sight distance at a specified location.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: SPD, ST14, ST5.

f. Formal parameters:

Name	Description
XX	Position at which passing sight distance is evaluated for the direction of travel in process.

g. Common blocks: PAS, ROA, ST.

h. Local variables: None.

i. Modifications from TWOWAF: None.

j. Error messages: None.

72. Subroutine SLIN2

a. Purpose: SLIN2 stores data for vehicles crossing the start line. (Note: The start line is located at the furthest upstream user-specified data collection station, XSTA(1,JD).)

b. Approach: SLIN2 obtains the time of crossing the start line (TIN) from interpolation of the vehicle's position at the beginning and end of the review; TIN is stored in TVIN(IP) in tenths of a second as FLOAT (IFIX(TIN*10.))*10,000. TIN is also packed into the normal decimal registers of TVIN(IP). The time headway at the start line is calculated by differencing TIN with TINS(NLN,JD), which represents the time preceding vehicle crossed start line in same lane; SLIN2 increments the headway array to store these data. The vehicle is then processed as platoon member if following another vehicle (state 3 or 4), passing (state 5) with time headway less than 5 sec, or aborting a pass (state 6). If the vehicle is not platooned, SLIN2 retains the vehicle category and direction of travel as potential platoon leader (checked when the next vehicle is processed) and closes out the count of the previous platoon length. SLIN2 adds TIN/10,000 to the desired speed of the vehicle in process as code that vehicle crossed start line.

c. Synopsis: SLIN2 processes data for a vehicle crossing the start line of the simulated roadway.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: CXSTA.

f. Formal parameters: None.

g. Common blocks: Blank, CAR, LNCH, PLHDWY, ROA, STAT, TIM, TVIN, VEH.

h. Local variables:

Name	Description
IDD	Count of platoon length that has crossed in same lane as vehicle in process.
IDUM	Utility variable.
IHDW	Subscript for headway stratum.
IVCAT	Combined subscript for vehicle category and direction of travel, in range from 1 to 6.

Name	Description
JM	Factor (= JD-1) used in converting vehicle category to combined vehicle category and direction of travel subscript.
KVCAT	Vehicle category.
T	Time headway (sec) to previous vehicle crossing start line in same lane.

i. Modifications from TWOWAF: In TWOWAF, this logic was provided in Subroutine SLINE. Double subscripts have been added to retain the time of previous vehicle passage by lane as well as direction; but time headway strata are not separated by lane. Double subscripting was also added for platoon data by lane as well as direction. Each vehicle's crossing time is stored in TVIN(JP) rather than packed in the decimal part of VDNOR(IP), as in TWOWAF. The start line is located at XSTA(1,JD) rather than at distance XBUF from the upstream end of simulated roadway.

j. Error messages: None.

73. Subroutine SNAP2

a. Purpose: At user-selected times, SNAP2 prints data on the condition of every vehicle currently in the simulation in a format that reflects the vehicle sequence and direction of travel. Details of the printed output are provided in the TWOPAS User's Manual.[1] This printed output is known as a snapshot.

b. Approach: Pointers are used to select current vehicle data for printing in a physically meaningful sequence. Direction No. 1 data are in columns on the right side of page; Direction No. 2 data are in columns on the left side. Data for vehicles in the left and right lanes in a particular direction of travel are printed in the same columns. The lane occupied is distinguished by the packed state values, shown in the printed snapshot output.

c. Synopsis: SNAP2 prints snapshots with current data on all vehicles in simulation when routine is called.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: Main Program (TWOPAS).

f. Formal parameters: None.

g. Common blocks: EP, EPR, EXT, NVSIZ, ROA, TIM, VEH, VEL.

h. Local variables:

Name	Description
I	Index of loop.
II	Utility variable.
IX	Subscript of vehicle whose data are loaded into symbol names for printing.
I1	Utility variable, and subscript of vehicle in generic lane 1.
I2	Utility variable, and subscript of vehicle in generic lane 2.
J	Index of loop, and utility variable.
JH	Variable in determination of left column, right column prints.
JJ	Index of loop.
JL	Variable in determination of left column, right column prints.
JT	Sequence number of vehicle deferred from print.
K	Index of loop. Frequently subscript for left side print (= 1) or right side print (= 2).
KB(I)	I = 1, number of vehicles in print block for left side; I = 2 for right side.
KBN	Minimum number of vehicles in print blocks for left and right sides.
KBX	Maximum number of vehicles in print blocks for left and right sides, i.e., maximum of KB(1), KB(2).
KFL	Code for column sets to be printed on one line; = 1 for left set only; = 2 for right set only; = 3 for both left and right.

Name	Description
KK	Index of loop.
KLIM	Number of data blocks that if printed trigger a warning message. Defined as 40 in a data statement.
KLOOP	Count of data blocks printed.
KP(I)	Number of vehicles on side I to be printed; I = 1 for left side; I = 2 for right side.
KPP	KP(1)-1 or KP(2)-1.
K1	Unsubscripted form of KB(1).
K2	Unsubscripted form of KB(2).
K3	K1-1.
L	Generic lane number, may be zero to signal that associated vehicle is a dummy.
LOW	Lowest subscript (in LST(K,LOW)) not filled with a vehicle number.
LST(K,J)	Subscripts of vehicles available in a print block, potentially to be printed. K = side (1 = left side, 2 = right side); J = sequence number, in range from 1 to 7.
MIX(K)	Equals NIX(K,1)+NIX(K,2); = 1 if next vehicle is real in generic lane 1 only; = 2 if next vehicle is real in generic lane 2 only; = 3 if next vehicles are real in both generic lanes; = 0 if next vehicles in both generic lanes are dummies.
MP(I,K)	Integer data printed in Ith column of <u>integer data</u>, side K.
NIX(K,L)	Code for next vehicle on side K, generic lane L. Equals L if next vehicle is real; equals 0 if next vehicle is dummy.
NXV(K,L)	Data subscript for previous vehicle on side K, in generic lane L.
N1	Utility variable.

Name	Description
N2	Utility variable.
RR(J)	Data used to convert all positions to Direction No. 1 coordinates.

i. Modifications from TWOWAF: This routine replaces Subroutine SNAP in TWOWAF. The basic logic and print formats are unchanged. However, the routine was completely rewritten to provide for the possibility of added passing and climbing lanes.

j. Error messages: There is one warning message that currently does not terminate or redirect logic. It was used during debugging.

Message	Meaning
OUTPUT EXCEEDED LIMIT OF 40 DATA BLOCKS	Forty blocks of data, potentially for 560 vehicles, have been printed.

74. Subroutine SOUT(KTAB)

a. Purpose: SOUT is called after the simulation run is completed to process and print data collected in user-specified subsections of the simulated roadway identified by subscript KTAB. SOUT processes and prints data for for one user-specified subsection at each call.

b. Approach: First, local accumulators are initialized and reference time and speed values are assembled. The length of the data collection section is determined from the specified station subscripts that bound the subsection and station positions. The direction of travel is determined from the data subscript KTAB; KTAB has values 1 through 10 for Direction No. 1, and 11 through 20 for Direction No. 2. The maximum number of lanes available in the appropriate direction of travel at any point in the subsection is found from calls to PASZ2. The output for overall speeds and travel times is then assembled. Separate logic is used to assemble and print the data for subsections with one lane available and with two lanes available in the particular direction of travel.

c. Synopsis: SOUT processes and prints data for user-specified subsections.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: PASZ2, Z.

Called by: FPUT2.

f. Formal parameters:

Name	Description
KTAB	Subscript under which the subsection data are stored, in range from 1 to 10 for Direction No. 1, in range from 11 to 20 for Direction No. 2.

h. Local variables:

Name	Description
DUM	Utility variable.
⋮	
DUM4	1./(length of subsection in miles).
I	Index of loop.
IBSTA	Directional subscript for data station where subsection begins (upstream end).
IESTA	Directional subscript for data station where subsection ends (downstream end).
IL	Lane number (1 is single unidirectional lane or left lane of added passing or climbing lane; 2 is right lane of added passing or climbing lane).
ILC(J)	Count of lane changes over all vehicle categories for motivation J.
IO(I)	Count of vehicle reviews over both lanes for vehicle category I. Printed as sample sizes.
IOP(I,J)	Count of passes by vehicles in category I while in road zone with J lanes.
IVOL	Count, over all vehicle categories, of vehicles which traveled the data section from upstream start station to downstream end station.
J	Index of loop.
JDD	Direction of travel for data processed.

Name	Description
JH	Upper limit of loop over vehicle types.
JJD	Direction of travel.
JL	Lower limit of loop over vehicle types.
J1	Lower limit of loop over vehicle types.
J2	Upper limit of loop over vehicle types.
K	Index of loop.
KAT	Vehicle category.
KFN	Count, over all vehicle categories, of vehicles which traveled the data section from upstream start station to downstream end station.
KKTAB	Directional value of KTAB; equals KTAB for Direction No. 1; equals KTAB-10 for Direction No. 2.
LB1 through LB10	Headings to be printed.
MX	Largest station subscript in direction of travel JDD.
NLA	Maximum number of unidirectional lanes available anywhere within the data collection section.
XB	Directional position of upstream end of subsection (ft).
XDUM	Total distance traveled by all vehicles in a particular lane.
XE	Directional position of downstream end of subsection (ft).
XLC(I)	Lane change rate (changes/vehicle mile) associated with motivation I.
XLCC	Utility variable.
XLEN	Length of data collection section (ft).

Name	Description
XO(4,10)	Real variable output printed under the headings OVERALL SPEEDS and OVERALL TRAVEL TIMES AND DELAYS. Subscript range 4 for vehicle category and combined; subscript range 10 for columns.
XOP(4,2)	Passing rates (passes/vehicle mile). Subscript range 4 for vehicle categories and combined; subscript range 2 for passes with one unidirectional lane, and two unidirectional lanes, respectively.
XOU(4,8)	Data printed under headings PERCENT OF TIME UNIMPEDED, SAMPLE SIZES, and PERCENT OF TIME NEAR DESIRED SPEED. The subscript of range 4 is for vehicle category and combined; the range 8 subscript is for columns.
XVEXIT	Percent of vehicles exiting the data section that changed lanes to avoid the lane drop.

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

75. Subroutine SPDN(NCC)

a. Purpose: SPDN calculates accelerations for each constraint -- leader, crawl regions or curve speeds, performance limits, desired speed in conjunction with acceleration preferences, and the constraint on acceleration when being passed. SPDN also provides performance-limited maximum acceleration and calculates the new speed and position based on most restricted constraint, and determines the new state of the vehicle in process.

b. Approach: Calculates effect from each constraint and selects final values and state based on most restrictive constraint.

c. Synopsis: SPDN calculates new speed, position, and state for vehicle in process at end of each review interval.

d. Assumptions: When SPDN is called with NCC = 3, the acceleration values will have been set in previous call with NCC = 2.

e. Relationship to other subroutines:

Calls: CRFW2.

Called by: AL21, ST14, ST5, ST6.

f. Formal parameters:

Name	Description
NCC	Supplied by calling program, determines the parts of the program logic applied: when NCC = 1, SPDN performs the entire sequence of logic; when NCC = 2, SPDN calculates only accelerations based on individual constraints; when NCC = 3, SPDN assumes accelerations based on individual constraints have already been calculated and branches to selection of most restricted acceleration, the new speed, the new position, and the new state.

g. Common blocks: AEOL, AKPM, ALL, CAR, EP, EXT, FHP, GEO, LNCH, PAS, QUA, REUB2, REUB3, STA, TIM, VC, VEH, VEL, VIC, ZFFX.

h. Local variables:

Name	Description
A	Acceleration which is minimum of accelerations based on curves or crawl regions, driver preference, or vehicle capability moderated by driver restraint (ft/sec^2).
AC	Coasting acceleration for truck (ft/sec^2).
AP	Truck acceleration with clutch engaged and full throttle (ft/sec^2).
DUM	Utility variable.
ETAC	Parameter in equation for truck acceleration that is related to gear shifting effects. (Maximum engine speed in operating range/minimum engine speed) - 1.
IU	Leader speed in integer form (ft/sec).

Name	Description
IV	Follower speed in integer form (ft/sec).
RXFN	Formal parameter in call to CRFW2. Not used. Retained for conformance to calls to CRFLW in KLD version of TWOWAF.
VNC	New speed based on curve/crawl constraint (ft/sec).
VNP	New speed based on vehicle performance capability used with driver restraint (ft/sec).
WCAR	Logical variable, if true this means that the gap to the leader may constrain acceleration.
XD	The greater of 10 or the truck speed at start of review (ft/sec).

i. Modifications from TWOWAF: This was subroutine SPD in TWOWAF. The KLD version of TWOWAF dropped a check on the sight distance of vehicle in progress. This had been used previously to prevent a response to a leader that had not been in sight yet. This deletion is continued in TWOPAS.

The formal parameter NCC was introduced in TWOPAS. It permits the routine to generate all potentially restrictive accelerations needed by vehicles in added lane sections (NCC = 2), and completes the vehicle advance and state in a second call (NCC = 3).

j. Error messages: None.

76. Subroutine SSLOP

a. Purpose: SSLOP calculates the slopes of the upper and lower boundaries of the risk-acceptable region for possible entry by a lane changer. The region has position along the horizontal axis and speed along the vertical axis. For a usable region, the upper boundary is based on interaction with the gap leader; the lower boundary is based on interaction with the gap follower. The slopes have units (ft/sec)/ft. SSLOP is part of the sequence of computations initiated by Subroutine FAILG to examine gaps for possible future lane changes.

b. Approach: The program logic uses the array SGAP(7,7,40) which contains acceptable space gaps (ft) for a risk level and driver type combined in a 40-range subscript with leader speed equal to 20*(first subscript-1) and the interacting follower speed equal to 20*(second subscript-1). For a small spacing between the gap leader and the gap follower, the slope is based on a speed difference of 25 ft/sec that is made up of one

20-ft/sec step in the table speeds and a 5-ft/sec increment which would permit a 5-ft/sec slower follower to be only 4.0 ft behind a leader. The spacing is, therefore, the table value minus 4.0 ft. For a large spacing between the gap leader and the gap follower, the speed difference is 45 ft/sec consisting of two 20-ft/sec steps in the table plus the 5 ft/sec. The results are returned in COMMON/GDAT/ as ALOPL for the upper and ALOPF for the lower boundary.

c. Synopsis: Calculates slopes of the upper and lower boundaries of a region which is risk acceptable for entry by a lane changer.

d. Assumptions: It is assumed that a straight line approximations for the upper and lower boundaries of the risk-acceptable region is sufficiently accurate. The actual boundaries are concave upward. Consequently, the straight upper boundary, based on interaction with the gap leader, encompasses a small area that lies outside the true boundary. Likewise, the straight lower boundary, based on interaction with the gap follower, eliminates a small area that should lie inside the acceptable region.

e. Relationship to other subroutines:

Calls: None.

Called by: GDATA.

f. Formal parameters: None.

g. Common blocks: GDAT, LNCH, TAB.

h. Local variables:

Name	Description
IDAR	The combination of risk level code IA and driver type code KDR. IADR=IA+4*(KDR-1).
JUL	Subscript value for leader speed.
JVF	Subscript value for follower speed.
SLOPF	Slope for lower boundary based on 25-ft/sec speed difference [(ft/sec)/ft].
SLOPL	Slope for upper boundary based on 25-ft/sec speed difference [(ft/sec)/ft].

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

77. Subroutine SSTA(IDA,FRC)

a. Purpose: SSTA is called when the vehicle just processed has crossed or reached a station specified as start of subsection for data collection. SSTA calculates the time of crossing the station and packs it in TVIN(IP).

b. Approach: SSTA calculates time of crossing the station (TSTAI) from TIME and FRC. SSTA then packs TSTAI in TVIN without disturbing the time data packed above the 10,000 decimal place.

c. Synopsis: SSTA calculates and stores the time when the vehicle-in-process crosses the start line of an user-specified data collection subsection.

d. Assumptions: Simulation time will not exceed 9,999 sec.

e. Relationships to other subroutines:

Calls: None.

Called by: CXSTA.

f. Formal parameters:

Name	Description
IDA	Subscript for storing subsection data. (Not used; was incorporated for debugging.)
FRC	Fraction of the review interval spent upstream of the station.

g. Common blocks: CAR, TIM, TVIN.

h. Local variables:

Name	Description
TSTAI	Time when vehicle crossed or reached the station (sec).

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

78. Subroutine STOR2

a. Purpose: STOR2 accumulates counts and sums for each vehicle review where the vehicle is in the overall data collection section at the end of the review and simulation time is in the test time period.

b. Approach: STOR2 uses data increments accumulators with data on the processed vehicle's variable values at the beginning and end of a review interval.

c. Synopsis: STOR2 accumulates data for each vehicle review qualifying within the overall data collection section length and the test time.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: CXSTA.

f. Formal parameters: None.

g. Common blocks: Blank, CAR, FUL, INI, LNCH, ROA, SMR, TIM, VIC.

h. Local variables:

Name	Description
DUM	Speed change (ft/sec), and, later the acceleration (ft/sec^2) based on that change.
IDUM	Control integer, carries information about origins of process path.
IVCAT	Combined subscript vehicle category and direction of travel.
JM	Direction of travel minus one (JD-1).
JVT	Combined subscript for vehicle type and direction of travel.
KLAA	Temporary storage for KLSA(NLN).
KLS	Subscript for combined time margin and direction of travel strata.

Name	Description
KLSA	Subscript for combined overtaking acceleration and direction of travel strata. Extracted initially by generic lane but assembled and stored without reference to generic lane.
KLSV	Subscript for combined overtaking speed difference and direction of travel strata.
KLVV	Temporary storage for KLSV(NLN).
KVCAT	Vehicle category.
NM	Used in calculating speed difference and acceleration strata.
NZZ	Temporary storage for NSZ(NLN) which is used to count platoon length; later, when platoon count concludes, NZZ is subscript for platoon length strata.

i. Modifications from TWOWAF: This routine was named STOR in TWOWAF and is largely unchanged. Preparations were started during the development of TWOPAS to store data by generic lane so that several variables were expanded to arrays with subscript NLN, with values equal to 1 or 2. This was dropped in favor of the user-specified data collection stations and specification of user-specified interstation subsections. However, platoon data are assembled separately by generic lane.

j. Error messages: None.

79. Subroutine ST14

a. Purpose: ST14 processes vehicles for sections with a single lane in the direction of travel of the vehicle in process which have state designated as: (1) not impeded; (2) overtaking an impeder; (3) following an impeder; or (4) following an impeder with interest and performance capability to pass. ST14 also processes data and decisions on initiating a pass for vehicles is states 2, 3, or 4.

b. Approach: The leader which potentially will constrain the speed of the vehicle in process is located. A new speed, position, and state are calculated in a call to SPDN(1). If vehicle in process is impeded, a check of immediate leaders and followers continues to see if a pass might be initiated. Additional checks are made with respect to the next oncomer, the local passing and no-passing zones, the local sight distance, and the adequacy of acceleration. A partly stochasic decision is reached on initiating a pass if all preliminary tests are passed.

c. Synopsis: ST14 processes vehicles in a single lane section that are in states 1, 2, 3, and 4, i.e., free or following at the beginning of the interval processed.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: NXOCV, PASP, PASZ2, PTAID, PTRID, RAN, SGHT, SPDN.

Called by: Main Program (TWOPAS).

f. Formal parameters: None.

g. Common blocks: CAR, EXT, GEO, PAS, PPT, QUA, REG, ROA, STA, TIM, VC, VEH, VEL, VIC.

h. Local variables:

Name	Description
ALIM	Initial, and maximum, acceleration (ft/sec^2) for pass maneuver based on limit speed in pass.
DUM	Utility variable.
GMIN	Minimum space gap (lead + lag) which is acceptable after a projected pass.
IDUM	Utility integer, usually nonsubscripted form of subscripted integer.
IDUM1	Nonsubscripted form for vehicle type of third immediate leader of vehicle in process.
LIMA	Code: = 1 if acceleration performance is greater than acceleration normally used in pass; = 2 if not.
PRTM	Approximate time until projected pass completion (seconds).
RAND	Random number for pass acceptance decision.
RANO	Random number from call to RAN(4).
VIOLA	Speed of oncoming vehicle, nonsubscripted form with potential for negative sign (flag) removed.
VSUB	Projected speed at end of projected pass; used in calculation of GMIN.

i. Modifications from TWOWAF: The original TWOWAF contained a factor which reduced the probability of accepting a pass which would return to a gap between platoon members. KLD revised that factor to depend on directional flow (high flow reduces probability of acceptance). This dependence was retained in TWOPAS.

The tests of passing/no-passing zones in TWOPAS were revised to include 0 as code for a passing zone in the opposing direction to an added passing or climbing lane.

KLD incorporated restraints on passes that return between platoon members in TWOWAF. A minimum return gap size was based on the projected situation after passing vehicle(s) returned. This logic was retained in TWOPAS.

KLD reduced the upper bound on speed used in passing in TWOWAF. One modification was made to the KLD values in TWOPAS. In the KLD version of TWOWAF the upper bound was:

VLIM = DMIN1(DMAX1(VLDZ+15.,VIP),1.167*VC)

where VLDZ = speed of vehicle to be passed
VIP = initial speed of vehicle in process
VC = local desired speed which may be depressed due to curve or downgrade crawl

In TWOPAS, the above form is retained if the passing vehicle will enter a gap between platoon members. However, if the passing vehicle will reenter the normal lane in front of the platoon leader, then VLDZ = 15. is replaced by 1.167*VDNOR, where VDNOR is the passer's normal desired speed. The original KLD logic unduly restricted vehicles at low speed attempting to pass a very slow speed platoon leader.

In all versions of TWOWAF, the next oncoming vehicle (used in pass decision) was found with local logic in ST14. In TWOPAS, a call is made to NXOCV, a new routine.

In the original versions of TWOWAF, a vehicle did not respond to its leader unless that leader was in sight or had recently been in sight. KLD removed this logic in their revisions; it has not been replaced in TWOPAS.

j. Error messages: None.

80. Subroutine ST5

a. Purpose: ST5 processes vehicles in state 5, engaged in a passing maneuver.

b. Approach: A new speed and projected time margin are calculated by ST5. These are then used to decide either to abort or continue the passing maneuver. If the decision is to continue, ST5 recalculates the stage of the pass. If the decision is to abort, control is given to subroutine AMC.

In stage 4 of a passing maneuver, this routine calculates a decision on passing the next impeder if that vehicle is nearby.

c. Synopsis: ST5 processes vehicles engaged in a passing maneuver.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: NXOCV, PASZ2, PTRID, QUAD1, RAN, SGHT, SPDN.

Called by: Main Program (TWOPAS).

f. Formal parameters: None.

g. Common blocks: CAR, EXT, INI, NOV, PAS, QUA, REG, REUB1, REUB2, ROA, STA, TIM, VC, VEH, VEL, VIC.

h. Local variables:

Name	Description
AANZ	An alternative value of PTA, the passing time available; used only if less than standard.
AIZ	Acceleration of passer as limited by performance, preferences, and leaders.
DIS	Distance (ft) to pass limiting factor. (Depends on ITYPE.)
DUM	Utility variable.
DUM1	New speed of passer - new speed of impeder (ft/sec).
DUM2	Acceleration (ft/sec^2) of impeder ±18. Largest relative deceleration that could be achieved.
IDUM	Utility variable.
IDUM1	Vehicle type of next impeder.
IDUM2	Vehicle number of vehicle being passed.

Name	Description
IGI	General data subscript of vehicle being passed.
IHOLD	For IAGE = 4 only, the subscript of data for pass in progress.
0	Time remaining in opposing lane (sec).
PRTM	Approximate estimate of time remaining in opposing lane (sec).
PN	Random number from call to RAN(4).
TE	Time requried for passer to decelerate to speed of passed vehicle using -18 ft/sec^2 (sec).
VCLOS	Rate of closure of passer with oncomer or end of zone, whichever controls the passing decision (ft/sec).

i. Modifications from TWOWAF: For a single oncoming lane, the oncoming vehicle (established by NXOCV) is traced using the original TWOWAF logic, i.e., IOV(IDEX) which is updated if original oncomer is passed. With two oncoming lanes, NXOCV is called each review.

Tests on JPAS have been changed in TWOPAS to reflect the use of code 0 to represent passing zone with oncoming lanes.

j. Error messages: None.

81. Subroutine ST6

a. Purpose: ST6 processes vehicles which are aborting a pass, state 6.

b. Approach: Once a decision to abort a pass is made, this decision is not subject to revision as the simulation time advances. The aborting vehicle is held in the calculated position relative to the impeder where it will begin the lane change. It is held there until the calculated time has elapsed. During the lane change, the aborter vehicle responds to the impeder as a leader and also responds to road geometrics.

NOTE: SSAV is set equal to -1 when the aborter pass stage is greater than or equal to 3. The aborter will then be processed a second time in the same review period.

c. Synopsis: Processes vehicles aborting a pass.

d. Assumptions: Note the special description of variables for vehicle in or entering state 6.

VPM(IDEX)	=	Distance (ft) behind impeder where abort vehicle will begin return to normal lane.
TMRG(IDEX)	=	Time (sec) to elapse before return to normal lane begins.
ISTG(IDEX)	=	1, in passing.
	=	2, 3, 4, not used.
	=	5, beginning return to normal lane, one review remaining after review in progress.
	=	6, vacate pass lane at end of review.

e. Relationship to other subroutines:

Calls: SPDN.

Called by: Main Program (TWOPAS).

f. Formal parameters: None.

g. Common blocks: CAR, OSV, EP, EXT, INI, ROA, TIM, VC, VEH, VIC.

h. Local variables:

Name	Description
IDUM1	Impeder vehicle type.
IGI	Vehicle index or subscript of impeder.

i. Modifications from TWOWAF: None.

j. Error messages: None.

82. Subroutine TINC2(ITEND)

a. Purpose: TINC2 prepares to process vehicles in the next direction of travel. The simulation time is advanced and tested for end of the user-specified simulation duration. Note that JD is the direction just processed when TINC2 is called; JD is redefined to other direction within TINC2.

b. Approach: If JD is equal to 2, a check is made for end of the simulation duration. If the end of run is detected, ITEND is set equal to 1, and control is returned to the main program. Otherwise, TIME is advanced by the increment DELT and variables are set up for processing in the other direction (JD=1).

If JD is equal to 1, variables are set up for processing in the other direction (JD=2).

c. Synopsis: TINC2 readies tables and values required for processing vehicles in the next direction and time interval and tests for completion of specified simulation time.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: Main Program (TWOPAS).

f. Formal parameters:

Name	Description
ITEND	Code for simulation time: 0 = not completed, 1 = completed. Returned to calling program.

g. Common blocks: CAR, CARA, CV, CW, GD, GEO, INI, KTES, NOV, NX, PS, REG, REUB1, REGA, ROA, ST, STAT, TIM, VEH.

h. Local variables:

Name	Description
CVD	Coefficient, purpose now replaced by other logic.
IDUM	Index of loop.
IOL1	Subscript of upstream dummy vehicle in generic lane 1 of oncoming lanes; initiated as next oncoming vehicle in that lane.
IOL2	Same as IOL1, except IOL2 represents dummy vehicle in generic lane 2 of oncoming lanes.

Name	Description
J	Utility variable.
JJ	Index of loop.
K	Generic lane number, as subscript.

i. Modifications from TWOWAF: Subroutine TDINC supplied this logic in TWOWAF. TINC2 is a complete rewrite to accommodate the possibility of two lanes in each direction of travel, with the associated single and double subscripted tables. Also, when end of simulation time is detected, control is returned to main program which calls for final output. In TWOWAF, subroutine TDINC called FPUT for final output.

j. Error messages: None.

83. Subroutine TJCLL

a. Purpose: TJCLL calculates data for use in estimating the speeds and positions of the current lane leader at future times. If the vehicle in process has no intervening same lane leaders before the lane drop, logic sets JCM=0 and branches to return. TJCLL is part of the sequence of computations initiated by Subroutine FAILG to examine gaps for possible future lane changes.

b. Approach: TJCLL determines if the current lane is dropped. It then examines up to three vehicles ahead to determine JCM, the number of same lane leaders short of the lane drop. TJCLL then examines the most advanced leader for estimates of its future trajectory and uses those results to estimate the future trajectory of next rearward vehicle. This sequence continues until estimates are obtained for the immediate leader of vehicle in process.

TJCLL deals with projected interactions between leader-follower pairs in front of the vehicle in process. The interactions are estimated from the equation X-Y-4.-GHW*U ≧ .5*(V-U)**2/DAL, where the right-hand side = 0. for (V-U) < 0; where, X = position of rear of leader (ft); Y = position of nose of follower (ft); GHW = typical time gap in steady following (sec); U = speed of leader (ft/sec); V = speed of follower (ft/sec); DAL = typical deceleration (positive value) used by a vehicle closing on a slower leader (ft/sec^2). The equation is satisfied approximately in short time segments. Definitions of local variables refer to the left- and right-hand sides of the equation.

c. Synopsis: TJCLL obtains data to estimate future speeds and positions of the immediate leaders, if any, in currently occupied lane.

d. Assumptions: The trajectories of each of the current lane leaders over the next 10 sec can be adequately approximated in one to three time segments of assignable lengths, with an assignable constant acceleration in each segment.

e. Relationship to other subroutines:

Calls: None.

Called by: FAILG.

f. Formal parameters: None.

g. Common blocks: CAR, GDAT, LNCH, PAS, PLD, PS, REG, TIM, VC, VEH.

h. Local variables:

Name	Description
AYL	An acceleration (ft/sec^2) which would satisfy the steady following equation at the end of a time segment. That is, make the equation left-hand side equal zero.
AYR	An acceleration (ft/sec^2) which would eliminate dynamic interaction terms at end of a time segment by bringing follower to leader speed. That is, make the equation right-hand side equal zero.
AYT	A trial or test value for acceleration (ft/sec^2) of follower during a time segment.
DAEOL	The deceleration (a positive value) (ft/sec^2) normally used by a trapped vehicle approaching the end of the lane. Set equal to 10.5 in a data statement.
DAL	The typical deceleration (a positive value) used by vehicles when overtaking a slower leader. Set equal to 4.0 in a data statement.
DSTES	The time (sec) remaining in leader's time segment after a trial segment time of STES for the follower.
GHW	Typical time gap (sec) between a leader and follower in steady following. Set = 1.7 in data statement.
I	Index of loop.

Name	Description
IVTYP	Vehicle type code for leader of the leader-follower pair.
J	Subscript in a loop that shifts subscripted variable values.
JL	Subscript for the follower's time segment being processed.
JLL	Subscript for the leader's time segment involved in processing.
JT	Sequence number of leaders to vehicle in process. JT = 1 for immediate leader; JT = 2 for second leader; etc.
LLC	Vehicle subscripts used in the search through current lane leaders.
MSGL	Segment number for follower of leader-follower pair. Increments to the final maximum.
SL	Value of equation left-hand side when leader speed has been brought equal to follower speed in STES seconds of segment (ft).
SLE	Value of equation left-hand side at the end of a time segment when a selected acceleration has been used for the follower of a leader-follower pair (ft).
SLI	Value of equation left-hand side at the beginning of a time segment (ft).
SRE	Value of equation right-hand side at the end of a time segment when a selected acceleration has been used for the follower of a leader-follower pair (ft).
SREAR	Value of the argument (follower speed-leader speed) of equation right-hand side at the end of a time segment (ft/sec).
SRI	Value of equation right-hand side at the start of a time segment (ft).
SRIAR	Value of the argument (follower speed-leader speed) of equation right-hand side at the start of a time segment (ft/sec).

Name	Description
STES	Estimated or trial value for time segment (sec).
TZ	Segment time when follower of leader-follower pair stops; or for vehicle facing lane drop, the segment time when it stops (sec).
VNN	A reduced speed calculated for a follower at the beginning of a time segment (ft/sec).
VNNL	An alternative to VNN (ft/sec).
XCON	For a vehicle facing the lane drop, the position where it would normally begin decelerating from its current speed (ft).
XG	Calculated space gap when follower reaches zero speed behind a stopped leader.
XZ	Calculated position of a follower when it stops behind stopped leader.

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

84. Subroutine TRACE(I,R1,R2,R3,R4)

a. Purpose: TRACE is a debugging aid. TRACE prints integer I, and real variables R1, R2, R3, R4 when the logical variable YTRACE is TRUE.

b. Approach: See purpose.

c. Synopsis: See purpose.

d. Assumptions: The test variable YTRACE will be set TRUE in using programs when output is wanted. YTRACE is defined as FALSE in a data statement in TRACE.

e. Relationship to other subroutines:

Calls: None.

Can be called in: CRFW2, GENTB, SETFF, SETZK.

f. Formal parameters: See purpose.

g. Common blocks: YTRACE.

h. Local variables: None.

i. Modifications from TWOWAF: None.

j. Error messages: None.

85. Subroutine TRAJT

a. Purpose: This routine attempts to find future accelerations, linear in time, that are within preference and performance limits and that will take the lane changer into mesh with a specific target gap at a specific future time. TRAJT is part of the sequence of computations initiated by Subroutine FAILG to examine gaps for possible future lane changes.

b. Approach: Before calling this routine, the region of acceptable lane change speeds and positions has been assembled using data from Subroutine GDATA and has been trimmed by Subroutine GTRIM to reflect constraints.

In this routine, the approximate centroid of the risk-acceptable region is calculated as a speed (VCEN) and a position (XCEN). The acceleration requirements to reach the centroid are calculated as AICEN and AFCEN, where AICEN is the initial acceleration (at beginning of review) and AFCEN is the final acceleration (TTCL seconds after beginning of review). If these values are within driver preference and vehicle performance bounds, logic transfers to final tests.

If either or both of AICEN and AFCEN lie outside preference and performance bounds, the variables DAIM and DARM are calculated as mandatory changes from AICEN and AFCEN. The variables DVF and DYF are also calculated as the associated changes in final speed and position. Tests are made to determine if the off-centroid final conditions are within the acceptable region if acceptable logic transfers to final tests.

If the off-centroid final conditions are not acceptable, the failure code (KFAIL) is set equal to 5 and the variables YMISS and VMISS are calculated, where YMISS is the mandated final position, the nearby acceptable position and VMISS is the companion speed.

The final test logic tests for negative speeds during the maneuver and, if found, sets KFAIL equal to 6. Logic is incorporated to trap out cases in which intramaneuver speeds may exceed performance capability; however, this latter test logic is not incorporated.

If a gap to pursue is found, KFAIL is returned as zero and the required initial acceleration AIA is used in TRAJT to advance the vehicle in process. If a gap to pursue is not found, KFAIL is returned greater than zero. The meanings of the failure code, KFAIL, are as follows:

KFAIL	Meaning
1	No weight factors > 0. Data defective.
2	Failure to find acceptable rays encompassing ray from centroid to attainable speed/position.
3	Acceptable encompassing rays lead to a zero denominator.
4	Attainable speed/position probably lies outside acceptable region.
5	Attainable speed/position definitely does lie outside acceptable region.
6	Following the indicated acceleration sequence would lead to intramaneuver negative speeds.

c. Synopsis: TRAJT finds whether vehicle in process can attain a future acceptable speed and position to change lanes into a specific gap at a future time within 10 sec. If so, TRAJT processes vehicle forward in pursuit of that gap. A code returned to the calling routine indicates success or failure.

d. Assumptions: It is assumed that accelerations that are linear in time provide an adequate representation of maneuvering flexibility. Intramaneuver speeds and positive accelerations will not exceed vehicle performance capabilities. The trap for associated tests is contained in statements following 400 which currently makes a transfer to 900 accepting the calculated accelerations.

e. Relationship to other subroutines:

Calls: CALQD, DVOY.

Called by: FAILG.

f. Formal parameters: None.

g. Common blocks: AAMN, CAR, GDAT, IPTAR, QUA, TIM.

h. Local variables:

Name	Description
AFA	The final acceleration, at local time TTCL, in a successful projected pursuit of a gap (ft/sec^2).

Name	Description
AFCEN	The final acceleration in an acceleration sequence that would put the lane changer at the centroid of the acceptable speed-position region (ft/sec^2).
AFMX	The performance limited final acceleration based on limits at speed VCEN (ft/sec^2).
AIA	The initial acceleration, beginning of review, in a successful projected pursuit of a gap (ft/sec^2).
AICEN	The initial acceleration in an acceleration sequence that would put the lane changer at the centroid of the acceptable speed-position region (ft/sec^2).
COR(I)	Two coefficients used to test if attainable, final speed and position point is in acceptable region. Also used in calculating DVA, DYA, and VMISS, YMISS.
DAFM	Mandatory change in AFCEN to meet preference and performance constraints (ft/sec^2).
DAIM	Mandatory change in AICEN to meet preference and performance constraints (ft/sec^2).
DENOM	Denominator in solutions for the COR (I) (ft^2/sec).
DUM	Utility variable.
DVA	Difference in final speed: a speed at boundary of acceptable region - speed at centroid. (Both the final attainable condition and the boundary condition here lie on a ray from the centroid.) (ft/sec)
DVDYA(I)	Two variables used as formal parameters in calls to DVOY which returns DVDYA(I) as slope of a line: position abscissa, speed ordinate (ft/sec)/ft.
DVDYT	Formal parameter in call to DVOY which returns it as slope of a line (ft/sec)/ft.

Name	Description
DVF	Difference in final speed: attainable final speed - speed at centroid of acceptable region (ft/sec).
DYA	Difference in final position: the position coordinate difference corresponding to DVA (ft).
DYF	Difference in final position: attainable final position - position at centroid. The position coordinate difference corresponding to DVF (ft).
I	Index of loop.
J	Utility variable.
JJA(I)	Subscripts of apex rays, I = 1, 2, in search for apex rays that bracket ray to attainable final conditions.
JQDA(I)	Used as formal variable in calls to CALQD which returns JQDA (I), I = 1 or 2, as quadrant of supplied position/speed data.
JTARQ	Quadrant of ray to attainable final conditions as returned by CALQD.
J1	Smaller of subscripts for apex rays found to bracket the ray to attainable final conditions.
J2	Larger of subscripts for apex rays found to bracket the ray to attainable final conditions.
KONTA	Cumulative count of apexes in use.
KRAY(I)	Codes for angular positions of examined apex rays with respect to the target ray, the ray to attainable final conditions. KRAY(I) = -1 if apex ray is clockwise from target ray. = +1 if apex ray is counterclockwise or coincident with target ray.
VCEN	Speed value at approximate centroid of acceptable region in position-speed plane (ft/sec).
XCEN	Position value at approximate centroid of acceptable region in position-speed plane (ft).

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

86. Subroutine UNPC(KIN,KOUT)

a. Purpose: UNPC unpacks the data in KIN for those vehicles with multiple digit states in the range 1,000 to 4,999. KOUT is returned as the single digit state, 1 through 4. The routine also returns in COMMON/LNCH/: LOCC as the generic lane occupied, LTAR as the target lane, and MOT as the code for lane change motivation.

b. Approach: Each of the packed data elements is in the range 0 to 9 in decimal form. Unpacking is performed with decimal arithmetic. MOT is in the units place; LTAR in the tens place; LOCC in the hundreds place; and KOUT in the thousands place.

c. Synopsis: Unpacks data from KIN the multiple digit form of vehicle state with KIN in the range 1,000 to 4,999.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: ADV2.

f. Formal parameters:

Name	Description
KIN	Packed, multidigit, state in the range 1,000 to 4,999. Supplied by calling routine.
KOUT	Single digit vehicle state, range 1 through 4. Returned.

g. Common blocks: LNCH.

h. Local variables: None.

i. Modifications from TWOWAF: None, new routine in TWOPAS. Recognize, however, that in previous versions of TWOWAF a multiple digit form of vehicle state was used with the range 5,000 to 6,999. This form is still in use in TWOPAS and is packed and unpacked by other logic.

j. Error messages: None.

87. Subroutine UPSS(KVTE,VDNRE,JDE,SUPS)

a. Purpose: UPSS calculates an upstream, overall free speed SUPS for vehicle type KVTE with desired speed VDNRE in direction JDE. This value reflects the effect of the user-specified upstream alignment on the choice of platoon leaders by program logic.

b. Approach: Upstream, overall free speeds are available in the array UPSP(ISTR,KVTE,JDE).

c. Synopsis: See purpose.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: EPLAT.

f. Formal parameters:

Name	Description
KVTE	Vehicle type. Supplied by calling routine.
VDNRE	Desired speed of vehicle (ft/sec). Supplied by calling routine.
JDE	Direction of travel. Supplied by calling routine.
SUPS	Upstream overall free speed (ft/sec). Returned to calling routine.

g. Common blocks: UPE, VEL.

h. Local variables:

Name	Description
KV	Vehicle category.
SDV	The deviation of desired speed VDNRE from the mean VEAN in standard deviations.
DENOM	The denominator of the weight factors used in linear interpolation.

Name	Description
WT1	Weight factor for tabular speed with smallest subscript in interval of interest.
WT2	Weight factor for tabular speed with largest subscript in the interval of interest.

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

88. Subroutine VASGN

a. Purpose: VASGN calculates the desired speed for a vehicle of type KVT.

b. Approach: VELDST(J),J=2,14 is the cumulative normal distribution at intervals of 0.5 standard deviations from -3 to +3 standard deviations. Interpolation is made in the VELDST at a random number value for the equivalent fractional J. The desired speed is formed as the mean plus the deviation associated with J and the bias associated with vehicle category.

c. Synopsis: Calculates desired speeds.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: RAN.

Called by: VGEN, ZERO.

f. Formal parameters: None.

g. Common blocks: CAR, VEL, ZER.

h. Local variables:

Name	Description
DUM	Random number
DUM1	Deviation from the mean in standard deviations.

Name	Description
IDUM	Subscript of VELDST for VELDST just less than random number.
KAT	Vehicle category.
VELDST(I)	See approach.

i. Modifications from TWOWAF: None.

j. Error messages: None.

89. Subroutine VGEN

a. Purpose: VGEN is called by Subroutine ENTR after that routine has successfully placed an entering vehicle on the road. VGEN obtains the next vehicle to enter in the same direction of travel and calculates simulation time for its entry, guarding against vehicle data overflow; and, if this vehicle has exhausted the available arrays of entering platoons in direction JD, VGEN calls Subroutine EPLAT to reload those arrays.

b. Approach: VGEN selects next vehicle from a platoon stored in arrays of COMMON/PLAT/ which have previously been sequenced by Subroutine EPLAT to have a logical leader based on the user-specified upstream alignment. VGEN obtains the simulation time for entry by adding the vehicle's time headway to previous entry time. VGEN checks that the data subscript to be assigned will not encroach on eight values reserved for dummies. If the platoon arrays for direction JD are exhausted and vehicle selected is not the last available, VGEN calls EPLAT to load the entering platoon arrays.

c. Synopsis: Determines next vehicle to enter the simulated roadway in the direction of travel currently being processed.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: EPLAT, EXIT.

Called by: Main Program (TWOPAS), ENTR.

f. Formal parameters: None.

g. Common blocks: AKPM, BKPM, CAR, GEN, IDRT, PLAT, ROA, SPE, TIM, TRK, TVIN, VEH, XCOUNT, XHEAD, ZER.

h. Local variables:

Name	Description
J	Subscript in platoon arrays for vehicle being prepared.
JH	Maximum subscript in packed entry array for vehicles entering in direction JD being processed.
KDT	Driver type code or subscript.

i. Modifications from TWOWAF: In TWOPAS, the entering traffic streams are generated prior to simulation by Subroutine ENQUE. The entering traffic streams are processed as needed by EPLAT to place logical vehicles as platoon leaders and the resulting entering platoons are placed in arrays. Subroutine ENTR gets entering vehicles from these arrays, keeps books, and calls EPAT as needed.

j. Error messages:

Message: Standard index STORAGE exceeded at time X.

Meaning: Too many vehicles on simulated roadway. At time indicated, an attempt to prepare next entry vehicle would have used data subscripts reserved for the eight dummy vehicles. With current dimensioning, 992 vehicles are in the simulation when this message appears.

VGEN calls EXIT after the message is printed.

90. Subroutine WELD(IDM)

a. Purpose: WELD links the pointers for the leader and follower of a vehicle which is removed from the sequence or from a particular lane.

b. Approach: WELD sets JL and JF as the subscripts for the leader and the follower of the vehicle being removed. WELD redefines JF as the follower of JL, and JL as the leader of JF.

c. Synopsis: WELD links the pointers of adjacent vehicles when a vehicle between them is removed from the lane.

d. Assumptions: WELD must be applied before LD(IDM) and LG(IDM) are revised in a lane change by vehicle IDM.

e. Relationship to other subroutines:

Calls: None.

Called by: LCBOK.

f. Formal parameters:

Name	Description
IDM	Subscript of vehicle being removed from lane.

g. Common blocks: VEH.

h. Local variables:

Name	Description
JF	Subscript of vehicle initially following IDM.
JL	Subscript of vehicle initially leading IDM.

i. Modifications from TWOWAF: None, new routine in TWOPAS.

j. Error messages: None.

91. Subroutine XBSIG(SX2,SX,EN,XB,SIG)

a. Purpose: XBSIG calculates the arithmetic mean and standard deviation. All input and output to the routine are formal parameters.

b. Approach: If there is only one data point, both the average and standard deviation are returned as zero. Otherwise, XBSIG uses standard forms with N-1 weighting for standard deviation. If supplied data causes negative variance, the standard deviation will be returned as zero.

c. Synopsis: XBSIG calculates mean and standard deviation.

d. Assumptions: None.

e. Relationship to other subroutines:

Calls: None.

Called by: PAGE1, PAGE2, PAGE3, PAGE89.

f. Formal parameters:

Name	Description
SX2	Sum of data points squared. Supplied by calling routine.
SX	Sum of data points. Supplied by calling routine.
EN	Number of data points. Supplied by calling routine.
XB	Arithmetic mean. Returned to calling routine.
SIG	Standard deviation. Returned to calling routine.

g. Common blocks: None.

h. Local variables:

Name	Description
AV	Initially zeroed; later average.
STD	Initially zeroed; later variance and standard deviation.

i. Modifications from TWOWAF: None.

j. Error messages: None.

92. Subroutine XBUGO

a. Purpose: Prints five lines of data for use in debugging, especially debugging that involves the states of vehicles and their spacial sequences in available lanes. The printed lines are:

- Simulation time (sec).
- The vehicle subscripts 976 through 1,000 (most likely to be in use).
- The subscript of the leader to vehicle in line 2.

- The subscript of the follower to vehicle in line 2.

- The state (packed form) of vehicle in line 2.

b. Approach: XBUGO prints the simulation time, which will have been advanced at beginning of review processing. The routine prints all data from subscripted arrays. Note that if XBUGO is called while review is in process, part of data will reflect conditions at end of review; remainder will reflect data at beginning of review. If called while a vehicle is being processed, the data for that vehicle will reflect beginning of review conditions.

c. Synopsis: Prints debugging data on vehicle states and spacial sequences.

d. Assumptions: See Approach.

e. Relationship to other subroutines:

Calls: None.

Called by: Has been commented out, except in the main program after calls to print a snapshot with SNAP2.

f. Formal parameters: None.

g. Common blocks: TIM, VEH.

h. Local variables:

Name	Description
I	Subscript of vehicle; printed in line 2.

i. Modifications from TWOWAF: None.

j. Error messages: None.

93. Function Z

a. Purpose: Z protects against real variable values equal to zero.

b. Approach: If argument is > zero, the function value is returned as argument value. Otherwise, returns 10^{35}.

c. Synopsis: Replaces zero with large value.

d. Assumptions: Function is not meaningful with negative arguments.

e. Relationship to other subroutines:

Calls: None.

Called by: PAGE1, PAGE2, PAGE3, PAGE4, PAGE6, PAGE89.

f. Formal parameters:

Name	Description
X	Variable to be guarded against zero value.

g. Common blocks: None.

h. Local variables: None.

i. Modifications from TWOWAF: None.

j. Error messages: None.

94. Subroutine ZERO2

a. Purpose: ZERO2 calculates travel time for specified vehicle types in zero traffic, determines placement of primed vehicles, and places them on the simulated roadway. This routine is used prior to actual simulation processing.

b. Approach: Isolated vehicles are integrated through review periods along road using one of seven representative desired speeds. Program logic employs curve, crawl region, and grade data together with vehicle performance constraints and driver preferences on acceleration. When the mean desired speed is employed for a vehicle type and direction, the locations for prime vehicles are selected and associated vehicle data and pointers are set.

c. Synopsis: ZERO2 calculates zero-traffic reference travel times and places primed vehicles on the simulated roadway before simulation processing begins.

d. Assumptions: Vehicles are all primed into generic lane No. 1 and may be near to a drop of that lane. It is assumed that normal simulation processing will suffice to produce realistic vehicle positions before the end of the warmup period.

e. Relationship to other subroutines:

Calls: EXIT, FRAK, PACS, PASZ2, RAN, VASGN.

Called by: PRIM2.

f. Formal parameters: None.

g. Common blocks: AKPM, BKPM, CAR, CV, CW, EXT, FHP, GD, GEO, IDRT, INI, I7SPD, PAS, QUA, ROA, RTTBS, SMR, SPE, STAT, TIM, TVIN, VC, VEH, VEL, ZER.

h. Local variables:

Name	Description
AC	Acceleration (ft/sec^2) of truck during gear-shift coast.
AP	Acceleration (ft/sec^2) of truck during powered part of power/shift cycles.
DUM	Utility variable.
ETAC	(Maximum engine speed in operating range/minimum engine speed) - 1. For trucks.
FLOV	Accumulates (flow rate)*(distance/local speed). Places priming vehicle when FLOV = 1. Initialized as 0.5.
FRAKU	Fraction of review interval that vehicle was upstream of station at XXSTA.
ICDA	Data storage subscript specified for between station section(s).
IDUM	LG(LI), data subscript of follower for previous vehicle primed.
IRN	Driver type code or subscript, range 1,10.
JVT	Combined subscript for vehicle type and direction of travel.
KAT	Vehicle category, range 1,3.
MS	Maximum specified station number in direction processed.

Name	Description
NXSTA	Next station number to be encountered by vehicle.
RN	Random number, in range from 0.00 to 1.00.
TBS	Time vehicle crosses station which is the beginning of an interstation data collection section (sec).
TDUM	Overall travel time for vehicle type-desired speed processed in specified interstation section.
VC	Minimum of speed constraint (ft/sec) as set by curve and crawl.
VNC	Speed constraint (ft/sec) as set by curve and crawl but with deceleration not more severe than 4 ft/sec^2.
VNP	Performance limited speed at end of review period.
XD	Speed (ft/sec), with limit minimum, used in truck performance equations.
XXSTA	Location (directional) of next station to be encountered by the vehicle processed (ft).

i. Modifications from TWOWAF: Calls to PASZ2 are required in TWOPAS to determine if a primed vehicle is in added lane section. If so, the vehicle state is packed by PACS to an appropriate format. Tests are also required for station crossings and specified data collection sections to obtain reference overall travel times based on the seven desired speeds. The reference travel times over the entire test section are based on travel from first to last station for direction processed.

j. Error messages:

Message	Interpretation
STANDARD INDEX STORAGE EXCEEDED AT TIME, F10.3	The number of vehicles primed has filled all dimensioned data places. The time (sec) is the value for vehicle in process when overflow occurred. Routine then calls EXIT.

95. Function ZN

a. Purpose: Function to prevent zero integer value.

b. Approach: If argument > zero, function returns the value of the argument. Otherwise, returns 10^{35}.

c. Synopsis: Replaces zero integer with large value.

d. Assumptions: Function is not meaningful with negative arguments.

e. Relationship to other subroutines:

Calls: None.

Called by: PAGE1, PAGE4, PAGE5, PAGE6, PAGE7.

f. Formal parameters:

Name	Description
N	Integer to be guarded against zero value.

g. Common blocks: None.

h. Local variables: None.

i. Modifications from TWOWAF: None.

j. Error messages: None.

APPENDIX B

DESCRIPTION OF COMMON BLOCKS

APPENDIX B

DESCRIPTION OF COMMON BLOCKS

COMMON AAMN

Variable	Description
AAMN	Minimum acceleration that can be used by vehicle in process for one review; part of the constraints on the lane-changing maneuver. Returned by Subroutine CLPRM as AMN.
AAMX	Maximum acceleration that can be used as above. Returned by Subroutine CLPRM as AMX.

COMMON ADJ

Variable	Description
X1	Direction No. 1 position of geometric feature requiring print in OPUT.
X2	Direction No. 2 position corresponding to X1.
PRECIS	Precision in test for equality (10^{-5}).

COMMON AEOL

Variable	Description
AEOL	Upper bound on acceleration. AEOL is calculated for vehicle attempting to change lanes to avoid the lane drop at the end of a passing or climbing lane. If this acceleration were used, it would position the vehicle in process 5.0 ft short of the lane drop at end of the review in process. AEOL is used only if a lane change can be made by the end of the review in process.

COMMON AKPM

Variable	Description
AKPM(IP)	Car-following coefficient assigned to vehicle with index IP. AKPM(IP) has one of 10 values BKPM(IDR), IDR=1,10.

COMMON ALL

Variable	Description
ALLJ(I)	Designation of first eight elements of ALL in BLOCK DATA, elsewhere referred to as AL1 through AL8.
UNL4	Intermediate value in calculation of leader restrained speed.
GP	The greater of GAP or zero.
UNL	New speed based on leader.

COMMON BKPM

Variable	Description
BKPM(IDR)	Car-following coefficient associated with driver type IDR, IDR=1,10. Values used in current project are: .43, .51, .57, .654, .76, .91, 1.13, 1.34, 1.58, and 2.12.

COMMON/blank/

Variable	Description
IPLDF(I)	Combined index for vehicle category and direction of travel of vehicle which is platoon leader (or potential platoon leader) in direction JD at finish line.
IPLDS(JD)	Combined index for vehicle category and direction of travel of vehicle which is platoon leader (or potential platoon leader) in direction JD at start line.
JHDWF(IHDW)	Number of time headways at finish line in size-direction of travel stratum IHDW.
JHDWS(IHOW)	Number of time headways at start line in size-direction of travel stratum IHDW.
JPLDF(IVCAT)	Number of platoon leaders at finish line by vehicle category and direction of travel. Leaders must be impeding.

COMMON/blank/ (cont'd)

Variable	Description
JPLDS	Number of platoon leaders at start line by vehicle category and direction of travel. Leaders must be impeding.
JSPD(IVCAT, ISPD)	Counts of vehicles with vehicle category and direction of travel IVCAT with overall speed in the speed stratum ISPD.
KPMF(JD)	Cumulative count of members in platoon currently crossing finish line.
KPMS(JD)	Cumulative count of members in platoon currently crossing the start line.
KZRO(IVCAT)	Number of primed vehicles which cross finish line; count by vehicle category and direction of travel.
MRBRT(KLS)	Number of abort margins by size and direction of travel strata KLS.
MRPS(KLS)	Number of passing time margins by size-direction of travel strata KLS.
NACC(JD)	Number of vehicle review intervals in direction JD. (For acceleration noise calculation.)
NBRT(IVCAT)	Number of pass aborts by vehicle category and direction of travel.
NLFT(IVCAT)	Number of "leap frog" pass terminations (passer's final headway less than 5 sec) by vehicle category and direction of travel.
NPASB(IVCAT)	Number of passes begun by vehicle category and direction of travel.
NPASE(IVCAT)	Number of pass extensions by vehicle category and direction of travel.
NPLTA(NSZ, KLSA)	Number of overtaking platoons by size stratum NSZ and initial acceleration-direction of travel stratum KLSA.
NPLTV(NSZ, KLSV)	Number of overtaking platoons by size stratum NSZ and speed difference-direction of travel stratum KLSV.

COMMON/blank/ (cont'd)

Variable	Description
NPMF(IDUM)	Number of platoons at finish line by size-direction of travel stratum IDUM. Platoon size includes leader.
NPMS(IDUM)	Number of platoons at start line by size-direction of travel stratum IDUM. Platoon size includes leader.
NSOP(JD)	Number of vehicles in operating speed sample, direction JD.
NSP(IVCAT)	The count of vehicles crossing the finish line, exclusive of primed vehicles, by vehicle category and direction of travel.
NST1(IVCAT)	Cumulative sums of vehicle review periods in State 1 by vehicle category and direction of travel.
NVPD(IVCAT)	Number of vehicles passed by vehicle category and direction of travel.
NVR(JVT)	Number of vehicle reviews of vehicle type and direction of travel.

COMMON BSPOT

Variable	Description
AMSP(3,2,20)	Cumulative vehicle speeds. Subscripts are: vehicle category, lane occupied, and subscript for user-specified subsection.
AMSP2(3,2,20)	Cumulative vehicle speed squared. Subscripts are the same as for AMSP.
AOTT(3,20)	Cumulative overall travel times (sec). Subscripts are: vehicle category, and subscript for user-specified subsection.
FTTVL(3,2,20)	Cumulative distance traveled by vehicles (ft). Subscripts are the same as for AMSP.
KDSPD(3,2,20)	Cumulative count of vehicle reviews in which vehicle speed was close to desired speed. Subscripts are the same as for AMSP.

COMMON BSPOT (cont'd)

Variable	Description
KFNL(3,20)	Cumulative count of vehicles traversing section from start to end. Subscripts are the same as for AOTT.
KREUN(3,2,20)	Cumulative count of vehicle reviews in which vehicle not impeded by other vehicles. Subscripts are the same as for AMSP.
KREV(3,2,20)	Cumulative count of vehicle reviews. Subscripts are the same as for AMSP.
KPAS1(3,20)	Cumulative count of passes performed where there was only one lane in the direction of travel of the passing vehicle. Subscripts are the same as for AOTT. The vehicle category is for the vehicle passing.
KPAS2(3,20)	Cumulative count of passes performed where there were two lanes in the direction of travel of the passing vehicle. (Such passes do not necessarily involve lane changes.) Subscripts are the same as for AOTT. The vehicle category is for the vehicle passing.
LCBYM(3,3,20)	Cumulative count of lane changes by motivation. Subscripts are: vehicle category, motivation, and subscript for user-specified subsection. Motivations are: 1=avoid lane drop, 2=move left to avoid delay, 3=move right.
LCDIS(5,20)	Cumulative count of lane changes made to avoid a lane drop by strata of distance from the lane drop. Subscripts are: distance stratum and subscript for user-specified subsection. The distance strata used are: (1)=less than zero, (2)=between zero and 200 ft, (3)=between 200 and 400 ft, (4)=between 400 and 600 ft, and (5)=600 ft or more.
LCPTD(7,20)	Cumulative count of lane changes made to avoid a lane drop by strata of projected time to reach the lane drop. Subscripts are: time stratum and subscript for user-specified subsection. The time strata used are: (1)=less than zero, (2)=zero to 1 sec, (3)=1 to 2 sec, (4)=2 to 3 sec, (5)=3 to 4 sec, (6)=4 to 5 sec, and (7)=5 sec and more.

COMMON BSPOT (cont'd)

Variable	Description
SSMN(3,2,20)	Minimum speed in any vehicle review interval. (Zero speed is excluded.) Subscripts are the same as for AMSP.

COMMON CAR

Variable	Description
COMPL	If immediate leader of the vehicle in process is passing (state 5), then COMPL is equal to leader length + 15 ft; otherwise, COMPL is equal to zero.
GAIN	Relative advance passer must make to clear impeder (ft).
GRD	Local grade at current position of vehicle in process in its direction of travel (decimal percent).
IAGE	Stage of vehicle in process at beginning of review interval.
IDEX	Subscript of extra data for vehicle in process when it is in state 5 or 6. (Otherwise = 0.)
IDR	A value of 1,2,3 which indicates that the first, second or third leader of the vehicle in process is being tested as a potential constraint or has been found to be a constraint.
IOL	Index of last identified oncoming vehicle.
IP	Vehicle index or subscript of vehicle in process.
KSIP	State of vehicle in process at beginning of review interval.
KSN	State (possibly new) of vehicle at end of review interval.
KT	Largest type code for vehicles using the truck performance equation (set equal to 4).
KVT	Vehicle type for vehicle in process; unsubscripted form for KV(IP).

COMMON CAR (cont'd)

Variable	Description
NAGE	Stage (possibly new) at end of review interval.
NRDX1	Index of extra data for immediate follower of vehicle in process.
NRDX2	Index of extra data for second follower of vehicle in process.
NRR1	Index of immediate follower to vehicle in process.
NRR2	Index of second follower to vehicle in process.
NRS1	State of immediate follower to vehicle in process. State packed in thousands place if greater than 4.
NRS2	State of second follower to vehicle in process. State packed in thousands place if greater than 4.
VDNR	Normal desired speed (ft/sec) of vehicle in process.
VIP	Speed of vehicle in process at beginning of review interval (ft/sec).
VN	New speed for vehicle in process at end of review interval (may be tentative).
XIP	Position of vehicle in process at beginning of review interval (measured in direction processed).
XN	New position of vehicle in process at end of review interval (measured in direction processed).

COMMON CARA

The variables in this COMMON block are ICARA(16,2) and RCARA(8,2). These double subscripted arrays store data for two lanes, comparable to COMMON/CAR/, which represents only a single lane. During simulation processing, the variables in COMMON/CAR/ are loaded with the data from COMMON/CARA/ for the lane containing the vehicle in process. The definitions below include the corresponding symbol name in COMMON/CAR/.

Variable		Description
COMMON/CARA/	COMMON/CAR/	
ICARA(1,LN)	IP	Vehicle index or subscript of vehicle in process.

COMMON CARA (cont'd)

Variable COMMON/CARA/	COMMON/CAR/	Description
ICARA(2,LN)	KSIP	State of vehicle in process beginning of review.
ICARA(3,LN)	KVT	Vehicle type of vehicle in process.
ICARA(4,LN)	IDEX	Subscript for extra data, if any.
ICARA(5,LN)	NRR1	Vehicle index or subscript of first following vehicle.
ICARA(6,LN)	NRR2	Vehicle index or subscript of second following vehicle.
ICARA(7,LN)	NRS1	State of first following vehicle (in added lane section still packed, i.e., four integer digits).
ICARA(8,LN)	NRDS2	State of second following vehicle (in added lane section still packed, i.e., four integer digits).
ICARA(9,LN)	NRDX1	Extra data subscript of first following vehicle.
ICARA(10,LN)	NRDX2	Extra data subscript of second following vehicle.
ICARA(11,LN)	KSN	State of vehicle in process at end of review.
ICARA(12,LN)	NAGE	Stage of vehicle in process at end of review.
ICARA(13,LN)	KT	Largest vehicle type code for trucks (always 4).
ICARA(14,LN)	IOL	Vehicle index or subscript of last found oncoming vehicle.
ICARA(15,LN)	IAGE	Stage of vehicle in process at beginning of review.
ICARA(16,LN)	IDR	Sequence number of leader, counting forward, that may be an impeder during review.
RCARA(1,LN)	XIP	Directional location of vehicle in process at beginning of review (ft).
RCARA(2,LN)	VIP	Speed of vehicle in process at beginning of review (ft/sec).

COMMON CARA (cont'd)

Variable COMMON/CARA/	Variable COMMON/CAR/	Description
RCARA(3,LN)	VDNR	Desired speed of vehicle in process (ft/sec).
RCARA(4,LN)	COMPL	The length of the immediate leader of the vehicle in process plus 15 ft, if the vehicle in process is in state 5.
RCARA(5,LN)	XN	Position of vehicle in process at end of review (ft).
RCARA(6,LN)	VN	Speed of vehicle in process at end of review (ft/sec).
RCARA(7,LN)	GD	Local grade (in direction traveled) at current position of vehicle in process (decimal percent).
RCARA(8,LN)	GAIN	Relative advance for vehicle in process to clear impeder when in state 5, indicating that the vehicle in process is passing in a normal two-lane section, or is passing in a section with two opposing lanes.

COMMON CHOZL

Variable	Description
AOH(3,3,2)	A coefficient in the speed function FSPD which is used to make initial lane choice at the beginning of an added passing or climbing lane. The first subscript is LFV, a code for lane favored by geometrics and markings: 1=left lane preference; 2=no lane preference; 3=right lane preference. The second subscript is JSTAT, the platooning status of the vehicle in process: 1=free vehicle; 2=platoon leader; 3=platoon member. The third subscript is JSZ, representing vehicle size: 1=large; 2=small; where large vehicles are the four truck types and the first two RV types; small vehicles are the second two RV types and the five passenger car types.
AONE(3,3,2)	A coefficient multiplied by vehicle speed in expression for the speed function FSPD used in lane choice at lane addition. The subscripts are the same as in AOH.

COMMON CHOZL (cont'd)

Variable	Description
BOH(3,3,2)	A coefficient in the speed function FSPD which is used to make initial lane choice at added lane. The subscripts are the same as in AOH.
BONE(3,3,2)	A coefficient in the speed function FSPD used in lane choice at lane addition. The subscripts are the same as in AOH.
CSMAX	Upper bound on second factor in expression for the probability of choosing the right lane at a lane addition.
CSMIN(3,3,2)	One of two potential upper bounds on second factor in expression for the probability of choosing the right lane at a lane addition. The subscripts are the same as for AOH.
CTCR(3,4,18)	First factor in expression for the probability of choosing the right lane at a lane addition. The first subscript is for LFV, as defined above in AOH. The second subscript is for platooning status with an added subdivision: 1=free vehicle; 2=platoon leader; 3=platoon member with preference and performance limits that prevent rapid speed gain over platoon leader; 4=platoon member with preference and performance capability to achieve rapid speed gain over platoon leader. The third subscript is a linear combination JSZ+2*(ITCR-1), where JSZ is vehicle size code defined above in AOH and ITCR is code for stratum of projected time (sec) before delay by vehicle in right lane: 1 represents less than 7.5 sec, 9 represents greater than or equal to 42.5 sec.
VFRE(3)	Potential speed gain over platoon leader required for classification as high performance follower (ft/sec). The subscript is LFV, as defined above for AOH.

COMMON CMTOUT

Variable	Description
CMTOUT(19,2)	Comment describing a particular run.
IRNOUT	Run number.

COMMON COND

Variable	Description
IPLC	Set equal to IP, the vehicle index or subscript of the vehicle in process, in Subroutine CONFD as code to indicate results from COND are available.
POC(5)	Position (ft) relative to the vehicle in process at beginning of potentially conflicting vehicles in the lane occupied by the vehicle in process. Subscript 1 is used for the second follower; subscript 2 for the immediate follower; and, subscripts 3,4, and 5 for immediate leader, second leader and third leader.
PTL(6)	Position (ft) of potential conflicting vehicles in the target lane, relative to vehicle in process, at beginning of review. Subscripts correspond to position sequence in regional table, with subscript 1 representing the farthest upstream vehicle.
VOC(5)	Speed (ft/sec) of potential conflictor in lane occupied by vehicle in process. See POC for subscript interpretation.
VTL(6)	Speed (ft/sec) of potential conflictor in target lane. See PTL for subscript interpretation.

COMMON CV

Variable	Description
MJCV(1)	Total number of horizontal curves counted in one direction. (Input data.)
MJCV(JD)	Maximum curve index used in JD direction. (During simulation processing.)
XCVN(JCV)	Location where horizontal curve JCV (counting in Direction No. 1) begins for No. 1 direction traffic, expressed in Direction No. 1 coordinates (ft). (Input data.)
XCVN(JCV)	Minimum position (ft) measured in direction of travel for which curve coefficients for horizontal curve JCV apply. (During simulation processing.)

COMMON CV (cont'd)

Variable	Description
CV1(JCV)	Coefficient of first power term in position dependent expression for restraint on mean desired speed due to horizontal curve JCV.
NJCV(JD)	Minimum curve index used in JD direction.
RCV(JCV)	Factor for standard deviation of desired speeds on horizontal curve JCV. A negative value is used as a flag for a curve to the right.
CV2(JCV)	Coefficient of second power term in position dependent expression for restraint on mean desired speed due to horizontal curve JCV.
JCVX(JD)	Largest index for horizontal curve regions in JD direction.
CVO(JCV)	Constant (ft/sec) in position dependent expression for restraint on mean desired speed due to horizontal curve JCV.

COMMON CW

Variable	Description
MJCW(JD)	Total number of input crawl regions in direction JD. (Input data.)
MJCW(JD)	Maximum crawl region index used in JD direction. (During simulation processing.)
XCWN(JCW)	Minimum position (ft) measured in direction of travel for which the coefficients for crawl region JCW apply. (During simulation processing.)
XCWN(KCW)	Beginning of crawl region KCW in JD direction. The values of KCW and XCWN are determined in the JD direction sense. The coordinate location is measured in the Direction No. 1 coordinates. (Input data.)
CW1(JCW)	Coefficient of first power term in position dependent expression for restraint on mean desired speed due to crawl region JCW.

COMMON CW (cont'd)

Variable	Description
NJCW(JD)	Minimum crawl index used in JD direction.
RCW(JCW)	Factor for standard deviation of desired speeds in crawl region JCW.
CW2(JCW)	Coefficient of second power term in position dependent expression for restraint on mean desired speed due to crawl region JCW.
JCWX(JD)	Largest index for crawl regions in JD direction.
CWO(JCW)	Coefficient in position dependent expression for restraint on mean desired speed due to crawl region JCW.

COMMON DIM

Variable	Description
ZD	Maximum number of grade regions. (Limit set by dimensions; ZD quantified in BLOCK DATA as 60.) Not referenced.
ZS	Maximum number of passing and no-passing zones. (Limit set by dimensions; ZS quantified in BLOCK DATA as 60.) Not referenced.
ZT	Maximum number of passing sight distance regions. (Limit set by dimensions; ZT quantified in BLOCK DATA as 60.)
ZV	Maximum number of horizontal curve regions. (Limit set by dimensions; ZV quantified in BLOCK DATA as 60.)
ZW	Maximum number of crawl and no-crawl regions. (Limit set by dimensions; ZW quantified in BLOCK DATA as 40.)

COMMON DRPL

Variable	Description
DEDL	Test distance from lane drop (ft). Used in avoidance of motivation to change into dropped lane and in motivation to exit from dropped lane.
DSGN	Test distance associated with lane drop signing and used in determining lane change motivation (ft).
TEOLHI	A test time (larger of two) compared with projected time (sec) to reach lane drop. Used in determining lane change motivation.
TEOLLO	A test time (smaller of two) compared with projected time (sec) to reach lane drop. Used in determining lane change motivation.

COMMON DSV

Variable	Description
VMV(JD)	VEAM*(CMD(JD)-CS(JD)). Used in calculating effects of driver work loads on JD direction vehicles. No longer implemented in TWOPAS.

COMMON EP

Variable	Description
CS(JD)	Factor for deviation of desired speed in direction JD. Accounts for encounter and passing work loads.
CM(JD)	Factor for mean desired speed in JD direction. Accounts for encounter and passing work loads.
EL(JD)	Encounter work load for JD direction drivers. (Vehicles encountered per second.)
ISD	Flag for collection of work load data; set equal to 0 when data are to be collected for a review interval.
NISD	Number of processing intervals after which driver work load data are updated. Also, number of initial intervals with continuous updating.

COMMON EP (cont'd)

Variable	Description
PL(JD)	Passing work load for JD direction drivers. Fraction of time spent in passing or abort maneuvers.
SV(JD)	Number of vehicles summed in JD direction for driver work load evaluation.
S56(JD)	Number of JD direction vehicles in states 5 and 6 during driver work load evaluation.
XCUM(JD)	Cumulative distance traveled by JD direction vehicles in driver work load sampling.

COMMON EPR

Variable	Description
RE	Control for encounter work load.
RP	Control for passing work load.

COMMON EXT

Variable	Description
IOV(IX)	Vehicle index or subscript for oncoming vehicle.
TMRG(IX)	Projected time margin in passing maneuvers. (Equal to PTA-TP.)
IPT(IX)	Vehicle index or subscript for vehicle being passed.
ISTG(IX)	Stage of pass or pass abort.
VPM(IDEX)	For passing vehicles, limiting maximum speed (ft/sec) in a passing maneuver. For aborting vehicles, distance (ft) behind impeder where aborter will reenter normal lane.

COMMON FHP

Variable	Description
FPO	Factor (usually = 0.73) to obtain sustainable maximum acceleration at zero speed. Used for passenger cars and RVs only.
FP1	Factor (usually = 0.90) to obtain sustainable maximum speed on zero grade. Used for passenger cars and RVs only.
TO(I)	Specification for simulated test time (input in minutes) for which extra data summary will be printed.

COMMON FUL

Variable	Description
FARRAY(I)	128-element integer array. Each element to contain packed data used to determine fuel consumption for a vehicle review interval.
FINDEX	Subscript of next element in FARRAY to be used.
IFUEL	Control for fuel consumption output. An input value of IFUEL less than or equal to -1 suppresses collection of fuel consumption data.
NRECDS	Number of 128-element arrays written as records to Unit 10.

COMMON GD

Variable	Description
MJGD(1)	Total number of grade regions, one way. (Input data.)
MJGD(JD)	Maximum grade region index used in JD direction. (During simulation processing.)
XGDN(I)	Position of beginning (both in Direction No. 1) of grade region I, counting in the Direction No. 1. (Input data.)

COMMON GD (cont'd)

Variable	Description
XGDN(JGD)	Position (ft) where grade region JGD begins, where the position and beginning are determined in the direction processed. (During simulation processing.)
NJGD(JD)	Minimum grade region index used in JD direction.
GO(I)	Grade (%) at XGDN(I) for traffic traveling in Direction No. 1. (Input data.)
GO(JGD)	Grade (%) at XGDN(JGD) for direction of travel being processed. (During simulation processing.)
JGDX(JD)	Largest index for grade regions in the JD direction.
G1(I)	The grade (%) at X(I) for traffic traveling in Direction No. 1. (Input data.)
G1(JGD)	Rate of change of grade (%/foot) beginning at XGDN(JGD) for direction of travel processed. (During simulation processing.)

COMMON GDAT

Variable	Description
ALOPF	Slope of upper boundary (based on gap follower) of risk-acceptable region (ft/sec)/(ft).
ALOPL	Slope of lower boundary (based on gap leader) of risk-acceptable region (ft/sec)/(ft).
CSPH	Rate of change for highest risk-acceptable speed at rear boundary of risk-acceptable region (ft/sec)/(sec).
CSPM	Rate of change for minimum risk-acceptable acceptable speed at front boundary of risk-acceptable region (ft/sec)/(sec).
FSPMO	Minimum acceptable speed at front boundary of risk-acceptable region, at current time (ft/sec).
KDGP	Code for initial evaluation of lane change gap in Subroutine GDATA: 1=may be usable; -1=not usable currently or in near future.

COMMON GDAT (cont'd)

Variable	Description
KFAIL	Code for outcomes of tests in attempting to change lanes to a particular target lane gap at a specific future time. Code 0 means the lane change has passed test just completed; otherwise, the value of KFAIL represents the reason for failure of the test. (See discussion of Subroutines GTRIM and TRAJT.)
NFW	Vehicle index or subscript for candidate new follower in search for target gap, accessible at a future time.
NFI	Not used.
RSPHO	Highest acceptable speed at rear of risk-acceptable region, at current time (ft/sec).
RWT(8)	Weight factors for apexes of the risk-acceptable region, and the constraint-adjusted risk-acceptable region: = 0 for nonexistent apex. = 0.01 for existing apex to be given small weight in estimating centroid. = 1.00 for existing apex to be given normal weight in estimating centroid.
SDROP	Limit for acceptable overall speed reduction (ft/sec) in maneuver for future interception of a target lane gap. (Dependent on lane change motivation and conditions.)
TTCL	Time (sec) until projected lane change can be made (i.e., the time length of gap interception maneuver), measured from the beginning of the current review interval.
VFW	Current speed of follower to gap appraised for future access (ft/sec).
VLD	Current speed of leader to gap appraised for fture access (ft/sec).
VMISS	One measure of failure from Subroutine TRAJT. VMISS is a speed difference: the final, future speed required to access the constrained, risk-acceptable region minus the final speed available within constraints (ft/sec).

COMMON GDAT (cont'd)

Variable	Description
VOMIS	The value of VMISS found with previously used, smaller value of TTCL. Used with VMISS in decisions on whether or not to examine the gap at more distant future time.
VVZA	Final speed that the vehicle in process would have after TTCL seconds with zero acceleration (equals VIP). (ft/sec)
VV(8)	Speed coordinates of the apexes of the risk-acceptable or the constraint-adjusted risk-acceptable region. Note that in Subroutine TRAJT, for computational purposes, the origin is translated through VV(I)=VV(I)-VCEN, where VCEN is the speed coordinate of the centroid of the constraint-adjusted risk-acceptable region (ft/sec).
XFWD	Position of rear of the risk-acceptable region at beginning of review in process (ft).
XLDO	Position of forward end of the risk-acceptable region at beginning of review in process (ft).
XXZA	Final position the vehicle would have after TTCL seconds with zero acceleration (ft).
XX(8)	Position coordinates of the apexes of the risk-acceptable or the constraint-adjusted risk-acceptable region. Note that in Subroutine TRAJT, for computational purposes, the origin is translated through XX(I)=XX(I)-XCEN, where XCEN is the position coordinate of the centroid of the constraint-adjusted risk-acceptable region (ft).
YBIG	The largest position coordinate on the boundary of the constraint-adjusted risk-acceptable region at time TTCL from beginning of current review (ft).
YLTL	The smallest position coordinate on the boundary of the constraint-adjusted risk-acceptable region at time TTCL from beginning of current review (ft).
YLOSL	The reduction in YBIG due to constraints imposed by the current lane leader or end-of-lane (ft).

COMMON GDAT (cont'd)

Variable	Description
YMISS	One measure of failure from Subroutine TRAJT. YMISS is a position difference: the final, future position required to access the constraint-adjusted risk-acceptable region minus the final position achievable within constraints (ft).
YOMIS	Value of YMISS found with previous, smaller value of TTCL. Used with VMISS in decision on whether or not to examine the gap at a more distant future time.
ZDY	Defined as XXZA-XCEN, the position of vehicle in process after TTCL seconds with zero acceleration minus the position coordinate of the centroid of the constraint-adjusted risk-acceptable region after TTCL seconds (ft).
ZODY	Value of ZDY found with previous, smaller value of TTCL. Used with ZDY in decision on whether or not to examine the gap at a more distant future time (ft).

COMMON GEN

Variable	Description
ACCPE(I,JD)	In direction JD, the cumulative probability of headway ≦ I for I = 1,10; ≦ (ID+(I-10)*TRO(JD)), for I = 11,20.
NXI(JD)	Vehicle index or subscript of next vehicle to enter in the JD direction.
TNTRY(JD)	Simulation time (sec) when next vehicle is due to enter in the JD direction.
TRO(JD)	Number of review intervals between entry headway probabilities for table subscripts 10-20.

COMMON GEO

Variable	Description
CCVO	Unsubscripted form of CVO(JCV) for region being processed.
CCWO	Unsubscripted form of CWO(JCW) for region being processed.
CUR	Desired speed constraint (ft/sec) of vehicle in process as result of horizontal curve or approach to horizontal curve.
GD1	G1(JGD)/100, for region being processed.
XCVT	Maximum position (in direction being processed) for current curve coefficients.
XCWMN	Unscripted form of XCWN(KCW) for region being processed.
RCVF	Unsubscripted form for RCV(JCV) in region being processed. Set negative as a flag for curves to the right.
KAI	Code set equal to 2 if vehicle in process being passed. Otherwise set equal to 1.
JCV	Index for horizontal curve region and associated coefficients.
CCV1	Unsubscripted form of CV1(JCV) for region being processed.
CCW1	Unsubscripted form of CW1(JCW) for region being processed.
CWL	Desired speed constraint (ft/sec) of vehicle in process due to downgrade crawl.
G	Acceleration due to gravity (32.17 ft/sec^2).
XCWT	Maximum position (direction being processed) for current crawl coefficients.
XGDMN	Minimum position for current grade coefficients. Also, position where GRD = GDO.
RCWF	Unsubscripted form for RCW(JCW) in region being processed.

COMMON GEO (cont'd)

Variable	Description
KCV	Control variable. Set equal to 2 if processing in region where horizontal curvature is not a factor; otherwise set equal to 1.
JCW	Index for crawl speed region and associated coefficients.
CCV2	Unsubscripted form of CV2(JCV) for region being processed.
CCW2	Unsubscripted form of CW2(JCW) for region being processed.
GDO	GO(JGD)/100, for region being processed.
CRW	Not used.
XGDT	Maximum position (in direction being processed) for current grade coefficients.
XCVMN	Unsubscripted form of XCVN(JCV) for region being processed.
ITRY	Status code for check on initiating pass. Equal 1, motivation not established; equal 2, motivated and opportunity; equal 3, no opportunity.
KCW	Control variable. Set equal to 2 if processing in region where crawl is not a factor; otherwise set equal to 1.
JGD	Index for grade region and associated coefficients.

COMMON IDRT

Variable	Description
IDRT(IP)	Driver type code (1 through 10) for vehicle with subscript IP.

COMMON I7SPD

Variable	Description
ISTR	Subscript for the seven representative desired speeds and weight factors.

COMMON INI

Variable	Description
IBRN	Control for various intra-routine branching.
LGD	Not used.
LI	Index of last inserted vehicle during priming, before simulation processing begins.
NSZ	Cumulative count of vehicle in platoon which overtakes; subsequently processed as subscript for platoon size strata.
ITES	Unity. Sign alternates each review internal. Used to control whether vehicle engaged in a pass makes a complete (+) or minor (-) review of the pass.
SSAV	Code set equal to -1 when a pass (state = 5) is aborted from a stage greater or equal to 3.

COMMON IPTAR

Variable	Description
IPTAR(IP)	The vehicle index or subscript of the gap follower at the gap targeted for future access by vehicle IP.

COMMON KATPL

Variable	Description
KATPL(2,40)	Vehicle category of most recent platoon leader that passed a particular station (second subscript) in a particular lane (first subscript). KATPL equals zero if a free vehicle passed most recently. (Of the 40 station numbers in linear array, 1 through 20 are reserved for Direction No. 1, and 21 through 40 for Direction No. 2.)

COMMON KATPL (cont'd)

Variable	Description
KTLC(2,40)	Vehicle category of most recent vehicle to cross a particular station (second subscript) in a particular lane (first subscript).
TLC(2,40)	Time that last vehicle crossed a particular station (second subscript) in a particular lane (first subscript).

COMMON KTES

Variable	Description
KTES	Code for whether test time has begun. KTES is equal to 0 during warm-up and greater than 0 during test time.

COMMON LNCH

Variable	Description
AOK	Acceleration used during review when a lane change is made (ft/sec^2).
IA	Code for limit risk level: 1 for -5 ft/sec^2, 2 for -10 ft/sec^2, 3 for -15 ft/sec^2, and 4 for 0 ft/sec^2.
IGO	Code for outcome of gap evaluation. Exiting from Subroutine EGAP: 0 means gap not accpetable; greater than 0 means gap accepted this review. (NOTE: the distinction between values greater than 0 was used for testing and debugging only.) Exiting from Subroutine FAILG: 0 means no future accessible gap found; less than 0 means a future accessible gap was found. (NOTE: the distinction between values less than 0 was used for testing and debugging only.)
IVF	Regional table sequence number of follower to target lane gap tested (in Subroutine EGAP) for acceptance in current review. IVF = 3 is most upstream unprocessed vehicle in target lane; lower-numbered vehicle are upstream, larger downstream.

COMMON LNCH (cont'd)

Variable	Description
JCEN	Of time remaining before reaching the lane drop, the center of time in which access to continuing lane is projected not to be blocked by other vehicles. Units are tenths of remaining time.
JFRE	Of time remaining before reaching the lane drop, the fraction in which other vehicles are projected to not block access to the continuing lane. Units are tenths of remaining time.
KDR	Code for driver type, 1 through 10.
LN	Lane occupied at beginning of review. A generic lane number: 1 = left lane, 2 = right lane. The value 1 is used where there is only one lane.
LOCC	Same as LN.
LTAR	Target lane number. See definition of generic lane number under LN. LTAR equals LOCC and LN when there is no motivation to change lanes.
MOT	Motivation to change lanes. MOT is equal to 6 through 9 for a lane change to move right; equal to 2 through 5 for move left to avoid delay; equal to 1 for avoid the lane drop. A negative sign is attached as a flag during the first review motivated. MOT is meaningful only if LTAR is not equal to LOCC.
NF	Vehicle index or subscript for new follower in lane change.
NLA	Number of unidirectional lanes available.
NLN	Lane occupied by vehicle in process at conclusion of review. See LN for generic lane number code.

COMMON MMXF

Variable	Description
MMXF	Regional table sequence number of most downstream vehicle that passed simple clearance test as potential new follower in target lane (from Subroutine EGAP).

COMMON MMXF (cont'd)

Variable	Description
MMNL	Regional table sequence number of most upstream vehicle that passed simple clearance test as potential new leader in target lane (from Subroutine EGAP).

COMMON NLANS

Variable	Description
NLANS(40)	Number of lanes available in one direction of travel at station with specified subscript. Subscripts 1 through 20 are reserved for Direction No. 1; 21 through 40 for Direction No. 2.

COMMON NOV

Variable	Description
NOV(JJL)	Next oncoming vehicle in opposing lane JJL, where JJL = 1 is the left of two oncoming lanes and JJL = 2 is the right lane. The left and right lanes are defined in the direction of travel of the vehicles that normally use these lanes.

COMMON NVSIZ

Variable	Description
NVSIZ	Dimension of arrays for data on individual vehicles in simulation. Defined as 1000 in BLOCK DATA.

COMMON NX

Variable	Description
NX	The directional subscript (range 1 through 20) for the next data station likely to be encountered as processing continues upstream.

COMMON OO

Variable	Description
OL(I)	The letters C, D, S, V, W, T, N, O and L for tests on second letter of the card type code on optional data cards.

COMMON PAG

Variable	Description
DNSPD(ID)	Count of overall speed measurements in ID direction (guarded against zero value).

COMMON PAS

Variable	Description
FACC	Factor in probability of passing where limited by sight distance. Equals 0.5 if approaching curve to right, otherwise is 1.0.
FACP	Factor in probability of passing. Equals 1.0 if passer is first follower; equals 0.53 for followers behind first.
GAP	Distance (ft) to leader that is influencing speed. Adjusted for prior processing of leader and leader passing if necessary.
ITYPE	Code for constraint on pass. Equals 1 if end of zone but no oncomer is in sight; equals 2 if neither zone end or oncomer is in sight; equals 3 if oncomer is in sight.
JPAS	Code for type of passing zone. Returned by Subroutine PASZ2.
PASB	Position (ft) of upstream end of pass zone (measured in direction of travel in process).
PASE	Position (ft) of downstream end of pass zone (measured in direction of travel in process).
POD	Passing opportunity distance (ft), from front of normal lane leader to front of next oncoming vehicle.

COMMON PAS (cont'd)

Variable	Description
POZ	Distance (ft) from front of impeder to end of passing zone.
PREC	Probability that driver will reconsider pass initiation during one review period.
PTA	Time (sec) available to perform or complete pass.
SGT	Passing sight distance (ft) from position of vehicle being processed.

COMMON PCT

Variable	Description
PCTSGN	Octal code for percent sign followed by blanks.
CHED(I)	Headings, defined in BLOCK DATA.
LT	Alphanumeric variable used to print LT in headings.
DHED(I)	Headings, defined in BLOCK DATA.

COMMON PCTOUT

Variable	Description
PCTOUT(6,2)	Not used.

COMMON PE

Variable	Description
CMO	Constant in equation for CM(JD), the work load factor for mean desired speed.
CEM2	Potential coefficient of encounter work load squared in equation for CM(JD). Not used.
CES1	Coefficient of encounter work load, EL(JD), in equation for CS(JD).

COMMON PE (cont'd)

Variable	Description
CPS2	Coefficient of passing work load squared in equation for CS(JD).
CESF	Largest permitted reduction in CS(JD) due to encounter work load.
CSO	Constant in equation for CS(JD), the work load factor for desired speed deviation.
CPM1	Coefficient of passing work load, PL(JD), in equation for CM(JD).
CES2	Potential coefficient of encounter work load in equation for CS(JD). Not used.
CEMF	Largest permitted reduction in CM(JD) due to encounter work load.
CPSF	Largest permitted reduction in CS(JD) due to passing work load.
CEM1	Coefficient of encounter work load, EL(JD), in equation for CM(JD), the work load factor for mean desired speed.
CPM2	Coefficient of passing work load squared in equation for CM(JD).
CPS1	Coefficient of passing work load, PL(JD), in equation for CS(JD), the work load factor for desired speed deviation.
CPMF	Largest permitted reduction in CM(JD) due to passing work load.

COMMON PLAT

Variable	Description
DSPE(N,JD)	The desired speed of the Nth vehicle in a platoon entering the simulated roadway in direction JD (ft/sec).
IPMS(JD)	Number of vehicles in platoon entering in the simulated direction JD (includes platoon leader).

COMMON PLAT (cont'd)

Variable	Description
KDTE(N,JD)	The driver type code for Nth vehicle in platoon entering the simulated roadway in direction JD.
KVTE(N,JD)	The vehicle type code for Nth vehicle in platoon entering the simulated roadway in direction JD.
NSQEZ(JD)	Count of review delays for entering vehicles in direction JD; subsequently compensated for by contracting long headways.
NXVP(JD)	Subscript (N) of next vehicle to be entered from the platoon array.
THWE(N,JD)	Time headway of Nth vehicle in platoon entering the simulated roadway in direction JD.

COMMON PLD

Variable	Description
AACL(N)	Acceleration used by a current lane leader during Nth segment of projected position and speed (ft/sec^2).
AACLL(N)	Final values are projected accelerations used by immediate leader in current lane during Nth segment of that vehicle's projected position and speed (ft/sec). (Used for leader's leaders during projection development in Subroutine TJCLL.)
JCM	Maximum count forward of leaders involved in making projections for immediate leader. (The maximum value of JCM is 3.) If JCM is equal to 0 constaints have not been imposed for the effect of current lane dropping. If JCM is greater than 0 lane drop effects, if any, have been imposed in projection for immediate leader.
KCLT	Code for current lane status. KCLT is equal to 1 if the current lane is dropped; KCLT is not equal to 1 if the current lane is not dropped.
KCLT1	Not used.

COMMON PLD (cont'd)

Variable	Description
MSGLL	Number of constant acceleration segments in projection of speed and position of the immediate leader in the current lane. (The maximum value of MSGLL is 3.) Note that N in these definitions is dimensioned 4 so that conditions at the end of the projection are available as XCLL(MSGLL+1),VCLL(MSGLL+1) at elapsed time TSSGN(MSGLL+1).
TCL(N)	Time span of Nth segment for a current lane leader (sec).
TCLL(N)	Final values are time spans of segments in projection of speeds and positions of the immediate leader in the current lane (sec). (Used for leader's leaders during development of projection in Subroutine TJCLL.)
TSSG(N)	Total elapsed time from beginning of review to beginning of Nth segment (sec). (TSSG(1)=0.)
VCL(N)	Speeds of a leader at beginning of Nth segment (ft/sec).
VCLL(N)	Final values are speeds of immediate leader in current lane at beginning of Nth segment (ft/sec). (Used for a leader's leader during development of projection in Subroutine TJCLL.)
XCL(N)	Positions of a leader at beginning of the Nth segment of projected positions and speeds (ft). (Position in this case is at rear of vehicle.)
XCLL(N)	Final values are positions of the immediate leader in the current lane at the beginning of the Nth segment of that leader's projected positions and speeds (ft). (Used for a leader's leader during development of projection in Subroutine TJCLL.) (Position in this case is at rear of vehicle.)

COMMON PLHDWY

Variable	Description
PLHDWY	Maximum time headway between platoon members and member-leader. Defined as 4.0 in BLOCK DATA.

COMMON PMOUT

Variable	Description
PMOUT(KVT,JD)	Difference in rates: conventional passes started minus passes aborted in units of passes/lane-mile-hour). Stratified by vehicle type and direction of travel.

COMMON PPT

Variable	Description
PP	Probability of accepting pass opportunity.

COMMON PS

Variable	Description
JPS(NN)	Code for type of passing zone.
LP	Subscript of passing zone found during most recent search.
MLP(JD)	Number of passing zones in the JD direction. (Input data.)
MLP(JD)	Maximum subscript for passing zones in the JD direction. (During simulation processing.)
NLP(JD)	Minimum subscript for passing zones in the JD direction.
XPZO(I)	Beginning of passing zone I, with beginning defined in the direction of travel in process, and the position (ft) defined in Direction No. 1 coordinates. (Input data.)
XPZO(I)	Beginning of passing zone I, with beginning defined ~~in the direction of travel in process and location~~ in that direction's coordinates. (During simulation processing.)

COMMON QUA

Variable	Description
ADPRF	Driver's preferred acceleration based on proximity of current speed to desired speed (ft/sec^2).
AIMP	Acceleration used (or projected to be used) by impeder in pass calculations (ft/sec^2).
ANC	Acceleration based on current speed and local curvature or downgrade crawl region (ft/sec^2).
ANL	Acceleration needed due to interaction with immediate leader (ft/sec^2).
ANZ	Not used.
AO	Maximum-power acceleration rate for vehicle in process at current speed and on local grade (ft/sec^2).
BZ2	Value of b/2 in the quadratic $x^2 + bx + c = 0$.
CVD	Set equal to 1.0 when processing Direction No. 1; set to 0.0 when processing Direction No. 2.
CZ	Value of c in $x^2 + bx + c = 0$.
FAO	Maximum acceleration at current speed and grade when driver restraint is used (ft/sec^2). (Note: FAO=AO for trucks.)
VMP	Not used.

COMMON RAMAX

Variable	Description
RAMAX	Upper limit on vehicle acceleration in KLD version of TWOWAF. Defined as 12.0 ft/sec^2 in BLOCK DATA. Not used in TWOPAS.

COMMON RE

Variable	Description
RE	Most extreme or emergency acceleration rate. Defined as -15.0 ft/sec^2 in BLOCK DATA.

COMMON REG

Variable	Description
JST(IRGN)	State of vehicle that is first, second or third leader of vehicle in process, based on value of IRGN.
JVT(IRGN)	Vehicle type of first, second or third leader of vehicle in process, based on value of IRGN. (Note: JVT is used as unsubscripted variable in input and output processing routines.)
XJ(IRGN)	Position (ft) of first, second or third leader of vehicle in process, based on value of IRGN, measured in direction of travel.
JSTAG(IRGN)	Stage of first, second or third leader of vehicle in process, based on value of IRGN, when that leader is passing.
TMG(IRGN)	Projected time margin (sec) for first, second or third leader of vehicle in process, based on value of IRGN, when that leader is passing.
JUL(IRGN)	If first, second or third leader of vehicle in process is passing, JUL(IRGN) is the vehicle index of the vehicle being passed. If first, second or third leader is aborting a pass, JUL(IRGN) is the vehicle index of the leader to be.
VJ(IRGN)	Speed (ft/sec) of first, second or third leader of vehicle in process, based on the value of IRGN.

COMMON REGA

The variables in this COMMON block are IREGA(12,2) and RREGA(9,2). These double subscripted arrays store data for two lanes, comparable to COMMON/REG/. During simulation processing, the variables in COMMON/REG/ are loaded with the data from COMMON/REGA/ for the lane occupied by the vehicle in process. Since these data are for leaders, they refer to conditions at the conclusion of review in process. The definitions below include the corresponding symbol name in COMMON/REG/.

Variable COMMON/REGA/	Variable COMMON/REG/	Description
IREGA(1,LN)	JST(1)	State of first leader in same lane. (State is unpacked, i.e., single digit.)
IREGA(2,LN)	JST(2)	State of second leader in same lane.
IREGA(3,LN)	JST(3)	State of third leader in same lane.
IREGA(4,LN)	JSTAG(1)	Stage of first leader in same lane.
IREGA(5,LN)	JSTAG(2)	Stage of second leader in same lane.
IREGA(6,LN)	JSTAG(3)	Stage of third leader in same lane.
IREGA(7,LN)	JUL(1)	Vehicle index or subscript for vehicle being passed by immediate leader in same lane; or, for an immediate leader aborting a conventional pass, the ultimate leader for the aborting vehicle.
IREGA(8,LN)	JUL(2)	Same as above but for second vehicle ahead.
IREGA(9,LN)	JUL(3)	Same as above but for third vehicle ahead.
IREGA(10,LN)	JVT(1)	Vehicle type for first leader in same lane.
IREGA(11,LN)	JVT(2)	Vehicle type for second leader in same lane.
IREGA(12,LN)	JVT(3)	Vehicle type for third leader in same lane.
RREGA(1,LN)	TMG(1)	Time margin for conventional pass in progress by first leader in same lane (sec).
RREGA(2,LN)	TMG(2)	Same as above for second vehicle ahead.
RREGA(3,LN)	TMG(3)	Same as above for third vehicle ahead.

COMMON REGA (cont'd)

Variable COMMON/REGA/	Variable COMMON/REG/	Description
RREGA(4,LN)	VJ(1)	Speed of immediate leader in same lane (ft/sec).
RREGA(5,LN)	VJ(2)	Speed of second vehicle ahead (ft/sec).
RREGA(6,LN)	VJ(3)	Speed of third vehicle ahead (ft/sec).
RREGA(7,LN)	XJ(1)	Directional position coordinate of immediate leader in same lane (ft).
RREGA(8,LN)	XJ(2)	Same as above for second vehicle ahead (ft).
RREGA(9,LN)	XJ(3)	Same as above for third vehicle ahead (ft).

COMMON REUB1

Variable	Description
RACEL(IDR)	Acceleration (ft/sec^2) of vehicle ahead in same lane that may be an impeder to vehicle in process. Subscript IDR is equal to 1, 2 or 3 and identifies which vehicle ahead was logically selected as potential impeder. Used in KLD version of TWOWAF where car-following logic required acceleration of leader. Still present in TWOPAS but not used.

COMMON REUB2

Variable	Description
RAL	Acceleration of vehicle ahead in same lane that may be an impeder to vehicle in process. RAL is set equal to RACEL(IDR) after IDR is selected from range 1 through 3. Used in KLD version of TWOWAF where car-following logic required acceleration of leader. Still present in TWOPAS but not used.

COMMON REUB3

Variable	Description
RB	Coefficient for nonlinear term in velocities in Pitt-KLD car-following model in TWOWAF. Set equal to 0.1 in BLOCK DATA. Retained in TWOPAS car-following model to mimic selected car-following features.
RC	Driver response delay in Pitt-KLD car-following model in TWOPAS. Set equal to 0.3 sec in BLOCK DATA. Retained in TWOPAS car-following model.

COMMON ROA

Variable	Description
ABUF(JD)	Length of test section (ft) in direction JD; i.e., distance from first to final data station in direction JD.
ANMIR(JD)	Reciprocal of test section length ($miles^{-1}$) in direction JD.
JD	Direction of travel being processed.
NXE	Next available unused subscript for extra data on individual vehicles.
NXS	Next available unused subscript for standard data on individual vehicles.
RL	Length of simulated roadway (ft).
VMTVPH(JD)	Multiplier to convert accumulated vehicle travel (ft) to volume (vph). Used to generate output on Subroutines PAGE1, PAGE6, and PAGE89.
XBUF	Originally, in TWOWAF, the buffer length (ft) at each end of road (warm-up length and equal cool down length). Now formally undefined, although used with value 0.0 in Subroutine OPUT.

COMMON RNS

Variable	Description
NSRAND(I)	Seeds for random number generation, I = 1,5. Also, last unscaled random number.
NSRAND(N)	Unscaled random numbers, always the seed for next number generated.

COMMON RTTBS

Variable	Description
RTTBS(ICDA,JD,KAT)	Reference travel time between stations for isolated vehicles on specified alignment. Initially expressed in seconds; later converted to seconds/mile. ICDA is the directional subscript for a user-specified station in the range 1 through 10; JD is the direction of travel; and, KAT is the vehicle category: 1 = trucks, 2 = RVs, 3 = passenger cars, and 4 = combined.

COMMON RVMAX

Variable	Description
RVMAX	Maximum speed. Defined as 120 ft/sec in BLOCK DATA. RVMAX was originally used in connection with Pitt-KLD car-following model in TWOWAF. Retained in TWOPAS.

COMMON SAVOUT

Variable	Description
SAVOUT(KVT,JD)	Flow rates from space measurements by vehicle category and direction of travel (veh/hr).

COMMON SCR

Variable	Description
TF(I)	Utility variable in assembling printed output.
CF	Utility variable in assembling printed output.
CF(I)	Utility variable in assembling printed output.
CLINE(N)	Equivalent of CF, C, MC, L9. Used in assembling printed output.
DIV(J)	Factors of form (100./total count) used to form percents in a variety of output calculations.
DLINE(N)	Equivalent of DF, D, MS, M9. Used in assembling printed output.
DF(I)	Utility variable in assembling printed output.
NN(I)	Utility variable in assembling printed output.
NUM1	Utility variable in assembling output.
NUM2	Utility variable in assembling output.
NUM3	Utility variable in assembling output.
TLINE(N)	Equivalent of TF, T, I9. Used in assembling printed output.

COMMON SMR

Variable	Description
DSIGD(ID)	Overall average speed (ft/sec) on ideal alignment for specified vehicle mix in direction ID.
GADSD(ID)	Average desired speed (measured) for direction ID (ft/sec).
SOPL(JD)	Sum of overall speeds (ft/sec) for vehicles qualifying in operating speed sample in direction JD.
SOPS(JD)	Sum of squared overall speeds (ft/sec^2) for vehicles qualifying in operating speed sample in direction JD.

COMMON SMR (cont'd)

Variable	Description
ZTDSD(ID)	Zero-traffic average speed (ft/sec) for specified flow in direction ID.
DVSM(IVCAT)	Sum of desired speeds which contribute to overall speed and time data for combined vehicle category and direction of travel subscript IVCAT.
SAMSC(IC)	Specified sample size for combined vehicle category and direction of travel subscript IC.
SPMIN(IVCAT)	Minimum overall speed (ft/sec) for vehicle category and direction of travel subscript IVCAT.
TVT(IVCAT)	Sum of overall travel times (sec) for vehicle category and direction of travel subscript IVCAT.
ZTDSC(IC)	Zero-traffic average speed (ft/sec) for specified vehicle category and direction of travel subscript IC.
SAMST(I)	Specified sample size for combined vehicle type and direction of travel subscript I.
SREF(KVT)	Performance-limited maximum speed (ft/sec) for vehicle type KVT on zero grade.
NSPVT(K)	Number of overall speed measurements for combined vehicle type and direction of travel subscript K.
SPMNVT(JVT)	Sum of overall speeds for combined vehicle type and direction of travel subscript JVT.
SPMINV(JVT)	Minimum overall speed for combined vehicle type and direction of travel subscript JVT.
ZTSP(ISTR,KVT)	Zero-traffic speed (ft/sec) through test section based on ZTMAT(ISTR,KVT). Assembled separately for each direction in repeated loop.
FNSPD(ID)	Count of vehicles (exclusive of primed vehicles) that cross finish line in direction ID.
SADSD(ID)	Specified mean desired speed (ft/sec) for direction of travel ID. (Variation with direction only through vehicle mix and category bias.)
SOPMN(JD)	Minimum overall speed (ft/sec) in sample used to determine operating speed in direction JD.

COMMON SMR (cont'd)

Variable	Description
VLIN(JD)	Cumulative sum of vehicle speed changes (ft/sec) by vehicle review period for direction JD.
VMD(J)	Vehicle-miles traveled in the test section by direction and for both directions combined.
FRCC(IC)	Specified fraction of directional flow for combined vehicle category and direction of travel subscript IC.
SMNVR(IC)	Number of vehicle review periods for combined vehicle category and direction of travel subscript IC (in test section during test time).
SPMN(IVCAT)	The sum of overall speeds by combined vehicle category and direction of travel subscript IVCAT.
TVT2(IVCAT)	Sum of squared overall travel times, (sec^2), by combined vehicle category and direction of travel subscript IVCAT.
SADSC(IC)	Specified mean desired speed (ft/sec) for combined vehicle category and direction of travel subscript IC.
SDIS(JVT)	Cumulative distance traveled (ft) by combined vehicle type and direction of travel subscript JVT.
ZTDST(J)	Same as JTV(JVT).
TVTVT(JVT)	Sum of overall travel times (sec) by combined vehicle type and direction of travel subscript JVT.
SPSIGV(JVT)	Sum of squared overall travel speeds, (ft/sec^2), for combined vehicle type and direction of travel subscript JVT.
DVSMVT(JVT)	Sum of desired speeds for combined vehicle type and direction of travel subscript JVT which contribute to overall speed and time data.
ZTV(JVT)	Weighted arithmetic average zero-traffic speed (ft/sec) through test section for combined vehicle type and direction of travel subscript JVT based on seven representative desired speeds.
FRCD(ID)	Specified fraction of directional flow rate in direction ID; normally either 1.0 or 0.

COMMON SMR (cont'd)

Variable	Description
SOPMX(JD)	Maximum overall speed (ft/sec) in the sample for operating speed, direction JD.
SAMSD(ID)	Specified sample size in direction ID.
VSOR(JD)	Cumulative sum of vehicle speed changes squared (ft/sec^2) for individual vehicle review periods for direction JD.
DSIGC(IC)	Overall average speed (ft/sec) on ideal alignment for specified vehicle mix for combined vehicle category and direction of travel subscript IC.
GADSC(IC)	Average desired speed (measured) for combined vehicle category and direction of travel subscript IC (ft/sec).
SPMAX(IVCAT)	Maximum overall speed (ft/sec) for combined vehicle category and direction of travel subscript IVCAT.
SPSIG(IVCAT)	Sum of squared overall speeds by combined vehicle category and direction of travel subscript IVCAT.
VM(IC)	Vehicle-miles for combined vehicle category and direction of travel subscript IC.
DSIGT(J)	Reference speed (ft/sec) for combined vehicle type and direction of travel on zero grade; weighted arithmetic average from seven representative desired speeds.
SPEC(I)	Specified flow rate (vph) for combined vehicle type and direction of travel subscript I.
ZTT(JVT)	Used initially in Subroutine ZERO2 as zero-traffic time (sec) through test section for combined vehicle type and direction of travel subscript JVT with one representative desired speed defined in a loop in Subroutine PRIM2. Used ultimately in PRIM2 as weighted average zero-traffic time (sec) through test section for combined vehicle type and direction of travel subscript JVT based on seven representative desired speeds.
TVT2VT(JVT)	Sum of squared overall travel times (sec^2) for vehicle type and direction of travel subscript JVT.

COMMON SMR (cont'd)

Variable	Description
SPMAXV(JVT)	Maximum overall speed (ft/sec) for combined vehicle type and direction of travel subscript JVT.
ZTMAT(ISTR,KVT)	Zero-traffic travel time (sec) through test section for vehicle type KVT with representative desired speed ISTR. Assembled separately for each direction in repeated loop.

COMMON SPE

Variable	Description
FRC(I,KVT)	Fraction of I direction flow that is composed vehicle type KVT.
SFLO(JD)	Specified flow rate, mixed vehicles per hour, in direction JD.

COMMON SPOT

Variable	Description
DRAT(KV,LLN,JTAB)	Summation of spot delay rates (sec/mile) at user-specified stations: by vehicle category (KV=1,3); generic lane LLN (1 = left, 2 = right); and station number JTAB, where station numbers 1 through 20 are reserved for Direction No. 1, and station numbers 21 through 40 are reserved for Direction No. 2.
KNT(KV,LLN,JTAB)	Count of vehicles at user-specified stations; see DRAT for subscripting.
KNTDS(KV,LLN,JTAB)	Count of vehicles near their desired speeds at user-specified stations. See DRAT for subscripting.
KNTUN(KV,LLN,JTAB)	Count of vehicles that are unimpeded by their leaders at user-specified stations. See DRAT for subscripting.
KPL(KV,LLN,JTAB)	Count of platoon leaders at user-specified stations. See DRAT for subscripting.

COMMON SPOT (cont'd)

Variable	Description
KPM(KF,LLN,JTAB)	Count of platoon members at user-specified stations by platoon leader vehicle category KF. See DRAT for subscripting.
SMN(KV,LLN,JTAB)	Minimum speed (ft/sec) at user-specified stations. See DRAT for subscripting.
SSP(KV,LLN,JTAB)	Summations of speeds (ft/sec) at user-specified stations. See DRAT for subscripting.
SSP2(KV,LLN,JTAB)	Summations of individual speeds squared at user-specified stations. See DRAT for subscripting.

COMMON ST

Variable	Description
MLS(JD)	Number of sight distance regions in direction JD. (Input data.)
MLS(JD)	Maximum subscript for sight distance regions in direction JD. (During simulation processing.)
SGTO(JST)	Sight distance (ft) at XSGO(JST), the beginning of the sight distance region JST. (Input data.)
SNOM	Nominal sight distance (ft). (Input data.) Used for regions where sight distance is not otherwise specified in input.
NLS(JD)	Minimum subscript of sight distance regions used in direction JD.
RST(JST)	Rate of change of sight distance (ft/ft) in sight distance region JST.
LS	Subscript of sight distance zone found during most recent search.
XSGO(I)	Location (ft) of beginning of sight distance zone I. (Input data.) Expressed in Direction No. 1 coordinates.
XSGO(I)	Same as input except location is in coordinate for direction of travel. (During simulation processing.)

COMMON ST (cont'd)

Variable	Description
SMIN	Minimum sight distance (ft). (Input data.) Used during simulation when other specifications indicate a smaller value.

COMMON STA

Variable	Description
VC	Minimum of curve- and crawl-limited speeds (ft/sec) for vehicle in process at XIP.
VNL	Speed (ft/sec) at end of review interval based on leader constraint.
U	Speed advantage of vehicle being processed over impeding vehicle (VIP minus leader speed at beginning of review interval).
PT	Not used.
TP	Time (sec) to perform pass. Estimate at pass initiation and in subsequent reviews.

COMMON STAT

Variable	Description
JCDA(20,2)	Double-subscript form for the code identifying which stations are boundaries for user-specified data collection subsections, where the directional station number is the first subscript and the direction of travel is the second subscript. The arrays actually used for subsection data storage are single-subscripted with a subscript equal to JCDA(I,JD)+(JD-1)*10. When JCDA = 0, subsection data are not collected.
MSTA(JD)	Maximum station number specified in direction JD, JD = 1,2.
PTDES(ISTA,JD,10)	Alphanumeric description of user-specified station ISTA in direction JD.

COMMON STAT (cont'd)

Variable	Description
XSTA(20,2)	Position (ft) of station identified by station number (first subscript) and direction of travel (second subscript). Data are read in Direction No. 1 coordinate; converted to directional coordinates in Subroutine PROCI.

COMMON SWT

Variable	Description
ISW	Code. Set equal to 1 in Subroutine REED2 when field 1-4 contains 1111. Causes STOP in main program.

COMMON TAB

Variable	Description
SGAP(JUL,JVF,IAIDR)	The space gap (ft) at the beginning of a review interval that would cause a driver type IDR to use an acceleration with code IA when leader speed is (JUL-1)*20 and follower speed is (JVF-1)*20, where IAIDR=IA+4*(IDR-1). IDR is the driver type in the range 1 through 10. IA is equal to 1 for -5 ft/sec^2, 2 for -10 ft/sec^2, 3 for -15 ft/sec^2, and 4 for 0 ft/sec^2.

COMMON TIM

Variable	Description
DELT	Length of review interval (normally = 1 sec).
ISNAP	Time intervals (simulated sec) between starts of snapshot output series.
NSNAP	Number of sequential snapshots at 1-sec intervals in each series.
TESHR	Test time in hours.

COMMON TIM (cont'd)

Variable	Description
TIME	Simulation time (sec) since processing began. (Also used as travel time in zero-traffic calculations.)
TIN	Used locally in FLIN2 and SLIN2 as simulation time at which vehicle in process crossed the start line.
TINS(NLN,JD)	Simulation time (sec) when previous vehicle crossed start line in lane NLN and direction JD.
TMAR	Projected time margin for pass completion (sec).
TOUTO(NLN,JD)	Simulation time (sec) when previous vehicle crossed finish line in lane NLN and direction JD.
TSP	Time measure of pass-suppressing influence of curve to right (usually 5.0 sec). (Input data.) Equivalent distance (ft) = 2*TSP*(Mean desired speed).
TTES	Test time. Time after warm-up during which data are collected. Input data in minutes; converted to seconds in the program.
TWRM	Simulation warm-up time before data are collected. Input data in minutes; converted to seconds in the program.

COMMON TOP

Variable	Description
NUMRUN	Run number. Read from first card in input deck.
COMENT(I)	Alphanumeric comment on run. Read from input deck and printed at several places on output.

COMMON TRK

Variable	Description
WOA(KVT)	Weight/projected frontal area ratio for truck type KVT (lb/ft^2).
CDE	Factor to correct aerodynamic drag of trucks from sea level to altitude.

COMMON TRK (cont'd)

Variable	Description
WOHP(KVT)	Weight/net horsepower ratio for truck type KVT (lb/NHP).
AD	Magnitude of deceleration used in calculating approach speeds to curves and crawls. Defined equal to 3.5 ft/sec^2 in BLOCK DATA.
CPE(KVT)	Factor to correct net horsepower for truck type KVT from sea level to altitude.

COMMON TTIOUT

Variable	Description
TTIOUT(KV,JD)	Reference speeds (ft/sec) on ideal geometrics (i.e., level tangents) by vehicle category and direction of travel.

COMMON TIMOUT

Variable	Description
TTMOUT(KV,JD)	Overall average speeds (ft/sec) by vehicle category KV and direction of travel JD.

COMMON TTSOUT

Variable	Description
TTSOUT(KV,JD)	Standard deviation of overall average speeds by vehicle category KV and direction of travel JD (ft/sec).

COMMON TVIN

Variable	Description
TVIN(IP)	For vehicle with vehicle index or subscript IP, TVIN(IP) stores the simulation times at which data stations are reached. TVIN(IP) contains two times. The time at which vehicle IP reached the previous data station is stored in normal registers of the real variables in seconds. The time at which vehicle IP reached the first data station (the overall start line) is converted to tenths of a second, multiplied by 10000, and packed into the leading digits of TVIN(IP).

COMMON UND

Variable	Description
UNDER	Hollerith data for minus sign.

COMMON UPE

Variable	Description
NUPG(JD)	Input specification of upstream geometrics and associated upstream speeds. NUPG(1), in range 1 through 3, specifies the second subscript NG for UPS(LA,NG). See explanation below.
UPE(LA,JD)	Tables of upstream overall speeds (ft/sec) used during simulation to select the vehicle with lowest upstream speed as the leader for each entering platoon. JD is equal to 1 for Direction No. 1; JD is equal to 2 for Direction No. 2. Subscript LA (in range 1 through 91) is a linearized version of the double subscript (ISPD,KVT), in the range from (1,1) through (7,13), where ISPD is subscript for desired speed and KVT is the vehicle type.
UPS(LA,NG)	Upstream overall speeds (ft/sec) defined in BLOCK DATA with NG equal to 1 for level terrain, NG equal to 2 for level terrain with sharp curves, and NG equal to 3 for a steep upgrade. Subscript LA is the same as that defined above in the discussion of UPE.

COMMON VC

Variable	Description
KC	Largest index for vehicle types that use downgrade crawl speeds.
FLG(KVT)	Length (ft) of vehicle type KVT.
CN(K)	Coefficient of $(\text{speed})^{-1}$ in equation for truck acceleration under power.
CO	Constant in truck acceleration during gear shifts (ft/sec^2).
PO(KVT)	Maximum acceleration (ft/sec^2), at zero speed on zero grade for passenger cars or RVs of type KVT.
C1	Coefficient of speed in equation for truck acceleration during gear shifts.
P1(KVT)	Maximum speed (ft/sec), on zero grade for passenger cars or RVs of type KVT. (Input data.) Converted to PO(KVT)/P1(KVT) for use as rate of change of acceleration with speed $(ft/sec^2)/(ft/sec)$.

COMMON VEH

Variable	Description
ACL(I)	Acceleration (ft/sec^2) used by vehicle I during last completed review.
KS(I)	State of vehicle I.
KV(I)	Vehicle type of vehicle I.
LD(I)	Index of leader to vehicle I.
LG(I)	Index of follower to vehicle I.
V(I)	Speed (ft/sec) of vehicle I at end of last interval processed.
VDNOR(I)	Normal desired speed (ft/sec) of vehicle I without adjustment for driver work load.
X(I)	Position (ft) of vehicle I, measured in vehicle's direction of travel.

COMMON VEH (cont'd)

Variable	Description
DVNOR(I)	Normal desired speed (ft/sec) of vehicle I. If vehicle has crossed the start line, the decimal fractional part will be scaled time (seconds) when start line was crossed; time/10,000.

COMMON VEL

Variable	Description
VEAN	Mean desired speed (ft/sec).
SIGSM	Lower limit of unbiased normal desired speeds (std. dev. from mean); for operating speed sample.
BGOP	Upper limit for desired speed, DVNOR(IP), to qualify in sample for operating speed (ft/sec).
VDD(ISTR)	Set of speeds (ft/sec) representing the distribution of desired speeds. (Used in calculating reference speeds.)
VSIG	Standard deviation of normal desired speeds (ft/sec).
SIGBG	Upper limit of unbiased normal desired speeds (std. dev. from mean); for operating speed sample.
VENTR(JD,KVT)	Upper bound on entry speeds (ft/sec) of vehicles of vehicle type KVT entering in direction JD. (Also input.)
WVD(ISTR)	Weight factors in each of seven speeds representing the distribution of desired speeds. Used in calculating reference speeds.
VBI(KAT)	Bias of normal desired speeds (ft/sec) for vehicle category KAT.
SMOP	Lower limit of desired speed, DVNOR(IP) to qualify for sample used in calculating operating speed (ft/sec).
VLIM	Limiting maximum speed for passing maneuver (ft/sec). Unsubscripted form for VPM(IDEX).

COMMON VEL (cont'd)

Variable	Description
SDVDD(ISTR)	Coefficients of standard deviation VSIG in expression to form speeds representing desired speed distribution VDD(ISTR).

COMMON VIC

Variable	Description
VLDN	Speed (ft/sec) of that leader which influences speed choice of vehicle in process.
VLDZ	Speed (ft/sec) of vehicle to be passed by vehicle in process.
XLDN	Position (ft) of front of leader to vehicle in process.
XLDZ	Position (ft) of vehicle to be passed by vehicle in process.
XRLN	Position (ft) of rear of that leader which influences the speed choice of vehicle in process.

COMMON XCOUNT

Variable	Description
XH(JD)	XH(JD) is an integer variable representing the subscript for the next vehicle to enter the simulated roadway in direction of travel JD. The value of XH(JD) is used to access data on the next vehicle from the XHEAD array described below in the discussion of COMMON/XHEAD/.
XHD(JD)	The total number of vehicles in entering traffic stream for direction JD (an integer variable).

COMMON XHEAD

Variable	Description
XHEAD(M)	XHEAD is an array of packed data for entering vehicles with: XHEAD = (IH+5)/10*2048 + KDT*64 + KVT where IH = time headway (sec*100) KDT = driver type KVT = vehicle type Data for entering vehicles in Direction No. 1 are stored in the range of M from 1 through XHD(1). Data for entering vehicles in Direction No. 2 are stored in the range of M from XHD(1)+1 to XHD(1)+ XHD(2).

COMMON XHMAX

Variable	Description
XHMAX	Maximum subscript for XHEAD array. (An integer variable.) Defined as 5000 in BLOCK DATA.

COMMON XNLP

Variable	Description
XNLP(100)	Normalized, cumulative exponential distribution. Used for entering traffic in KLD version of TWOWAF. Defined in BLOCK DATA. Not used in TWOPAS.

COMMON XPPL

Variable	Description
XPPL(JD)	Percent of traffic platooned traffic in direction of travel JD at entrance to simulated roadway. (Input data.) This percentage does not include leaders of platoons.

COMMON YTRACE

Variable	Description
YTRACE	Logical variable; if TRUE, YTRACE initiates calls to Subroutine TRACE, a debugging aid.

COMMON ZER

Variable	Description
FLOC	Flow rate (veh/sec) for vehicle type and direction of travel processed in Subroutine PRIM2.
VASN	Desired speed (ft/sec) for vehicle, returned from Subroutine VASGN.
VAV	Average speed (ft/sec) during interval processed in Subroutine ZERO2.
XAV	Not used.

COMMON ZFFX

Variable	Description
ZFFX(I,J)	Free flow distance threshold (ft). The first subscript represents the leader speed; the second subscript represents the follower speed.

COMMON ZK

Variable	Description
ZK(I)	A gap factor in the Pitt-KLD car-following model (sec), where I is equal to the follower speed (ft/sec) in the range from 1 through 100. This factor was incorporated in the KLD version of TWOWAF and has been retained in the revised car-following model in TWOPAS.

COMMON ZKCOR

Variable	Description
ZKCOR	Car-following sensitivity factor that applies to all driver types and speed situations in the Pitt-KLD car-following model. Also used in TWOPAS as a factor in ZK(I).

COMMON ZKF

Variable	Description
ZKF	Free flow density (veh/mile), a parameter in the calculation of ZK(1). Defined as 20.0 in BLOCK DATA.

COMMON ZKJ

Variable	Description
ZKJ	Jam density (veh/mile), a parameter in the calculation of ZK(I). Defined as 210.0 in BLOCK DATA.

COMMON ZL

Variable	Description
ZL	Calibration factor used in calculation of ZK(I). Defined as 2.2 in BLOCK DATA.

COMMON ZM

Variable	Description
ZM	Calibration factor used in calculation of ZK(I). Defined as 0.6 in BLOCK DATA.

COMMON ZPASPL

Variable	Description
ZPASPL(JD)	Factor to reduce probability of accepting a passing opportunity when return will be to gap within a platoon. ZPASPL was a constant equal to 0.52 in the original version of TWOWAF. The variable definition ZPASPL(JD) = EXP(-0.001*SFLO(JD)) was introduced in the KLD version of TWOWAF and has been retained in TWOPAS.

COMMON ZUF

Variable	Description
ZUF	Speed at free-flow density (mph). Used in calculation of ZK(I). Defined as 55.0 in BLOCK DATA.

COMMON ZVC

Variable	Description
ZVC(26,9)	Not used.