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DRIVER-VEHICLE EFFECTIVENESS MODEL
Volume II: Appendices

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16. Abstract

The Driver-Vehicle Effectiveness Model (DRIVEM) is a Monte Carlo simulation model intended for use by NHTSA to evaluate alternative vehicle subsystems or effects of legislative actions proposed to reduce the probability and severity of highway traffic accidents. This report describes work completed in DRIVEM Program phases II and III to refine and expand the model and implement model software on a NHTSA-designated computer facility.

Candidate DRIVEM applications were structured around subjects of the Federal Motor Vehicle Safety Standards (FMVSS); in particular, the 100 series (pre-crash) standards. Eleven scenarios representing potential accident situations to be simulated were developed based on review of accident literature and the relevance of these situations to DRIVEM applications was evaluated. Work on the model development task was concentrated in component areas of driver modeling and vehicle modeling.

The DRIVEM digital program was implemented in FORTRAN and demonstrated in a sample application to illustrate user procedures involved in a typical problem situation. Three primary activities were recommended to improve and verify the predictive capability of DRIVEM and its utility in applications of interest to NHTSA.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
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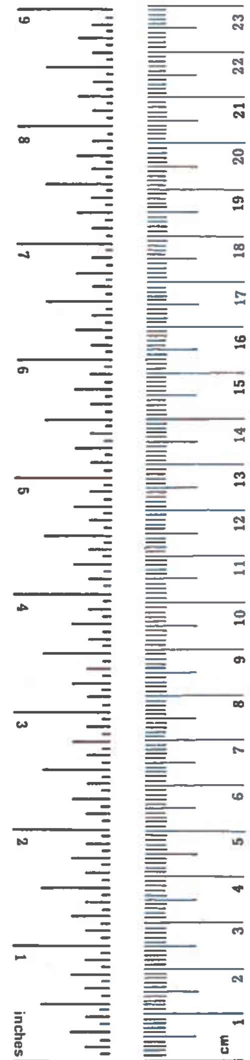
Unclassified	Unclassified	226	

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

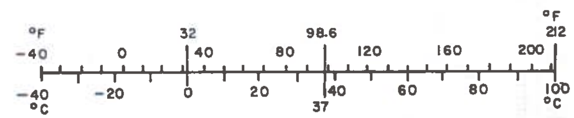
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



APPENDIX A

PROGRAM FLOW CHARTS

LIST OF ILLUSTRATIONS

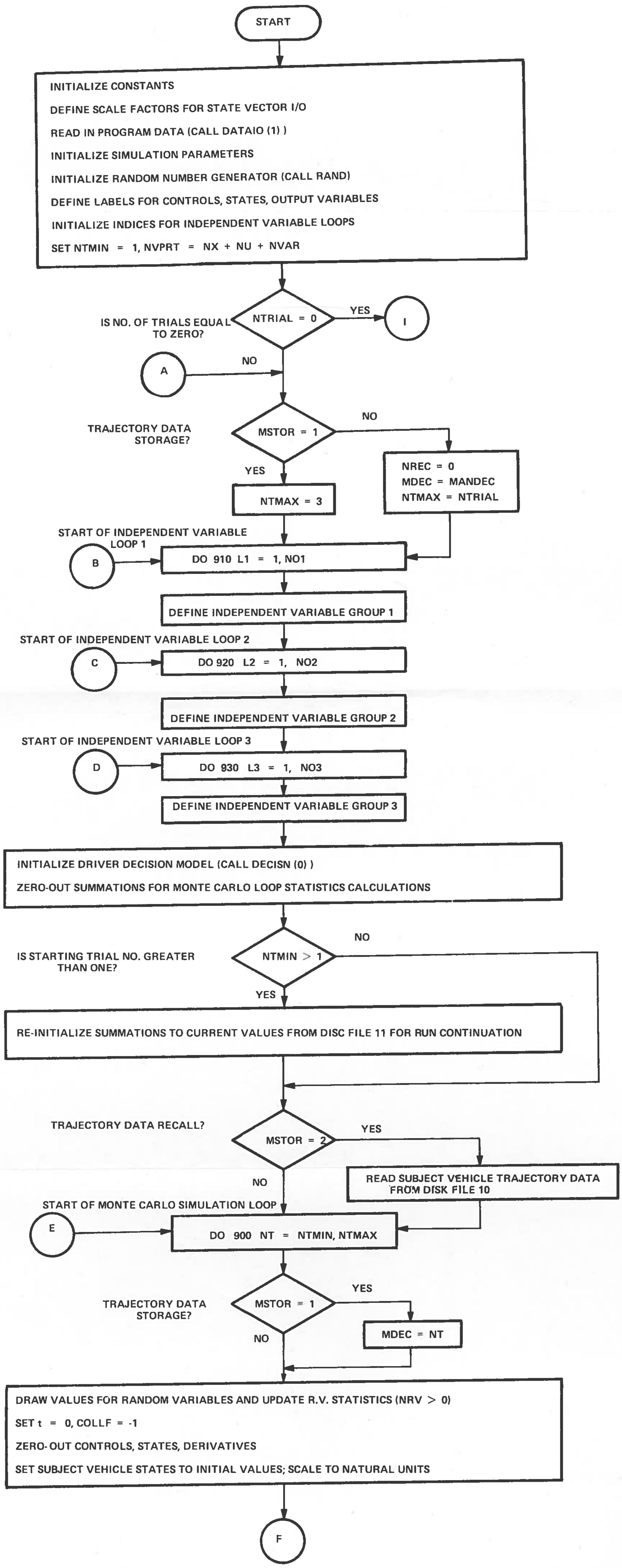


FIGURE A-1. MAIN PROGRAM FLOW CHART

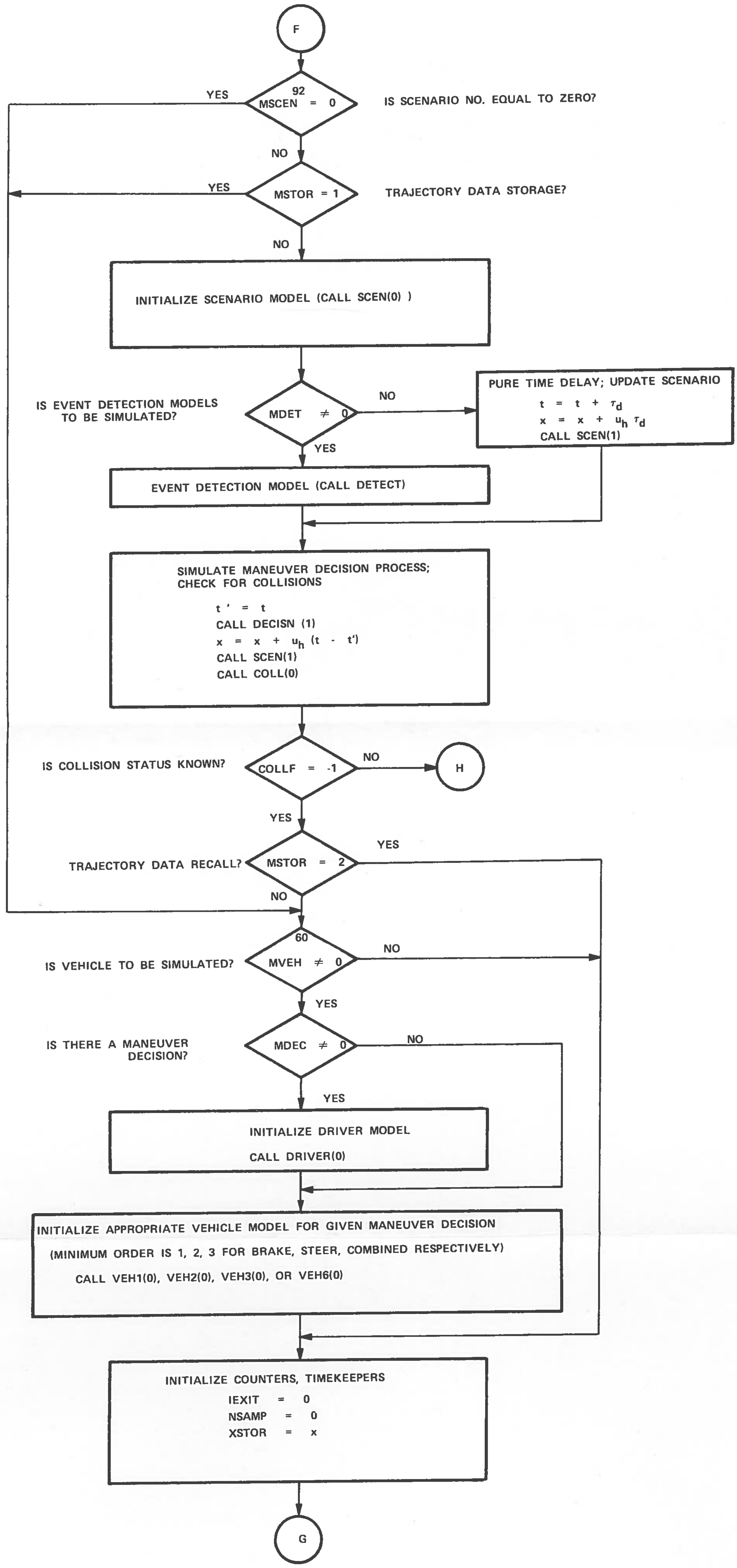


FIGURE A-1. MAIN PROGRAM FLOW CHART

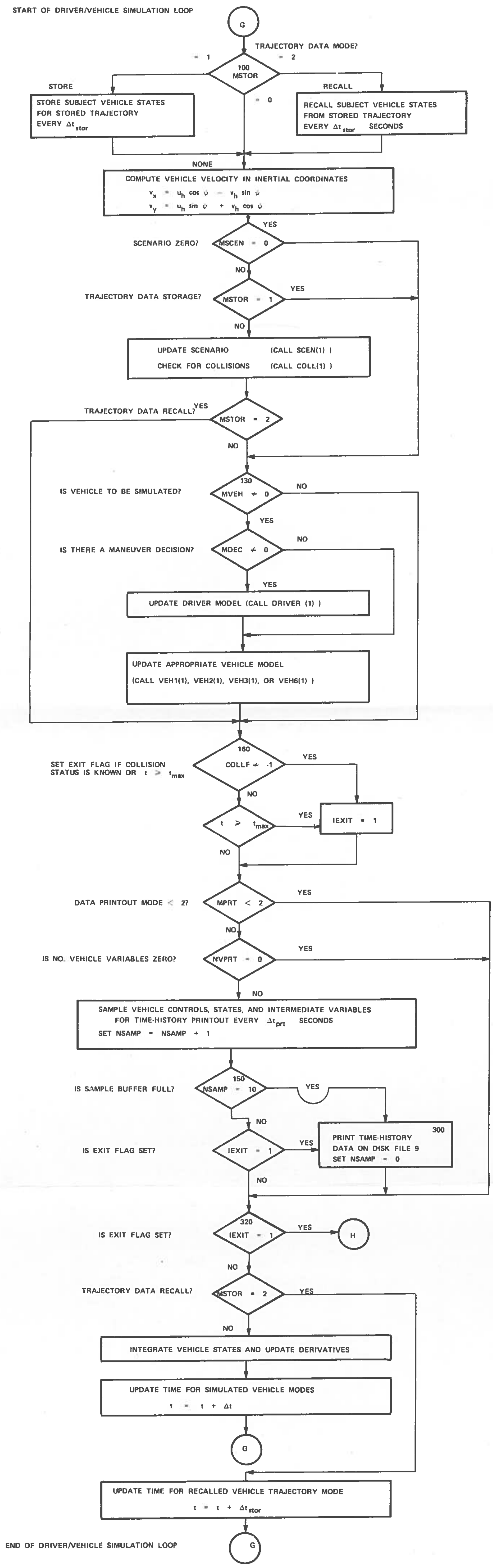


FIGURE A-1. MAIN PROGRAM FLOW CHART

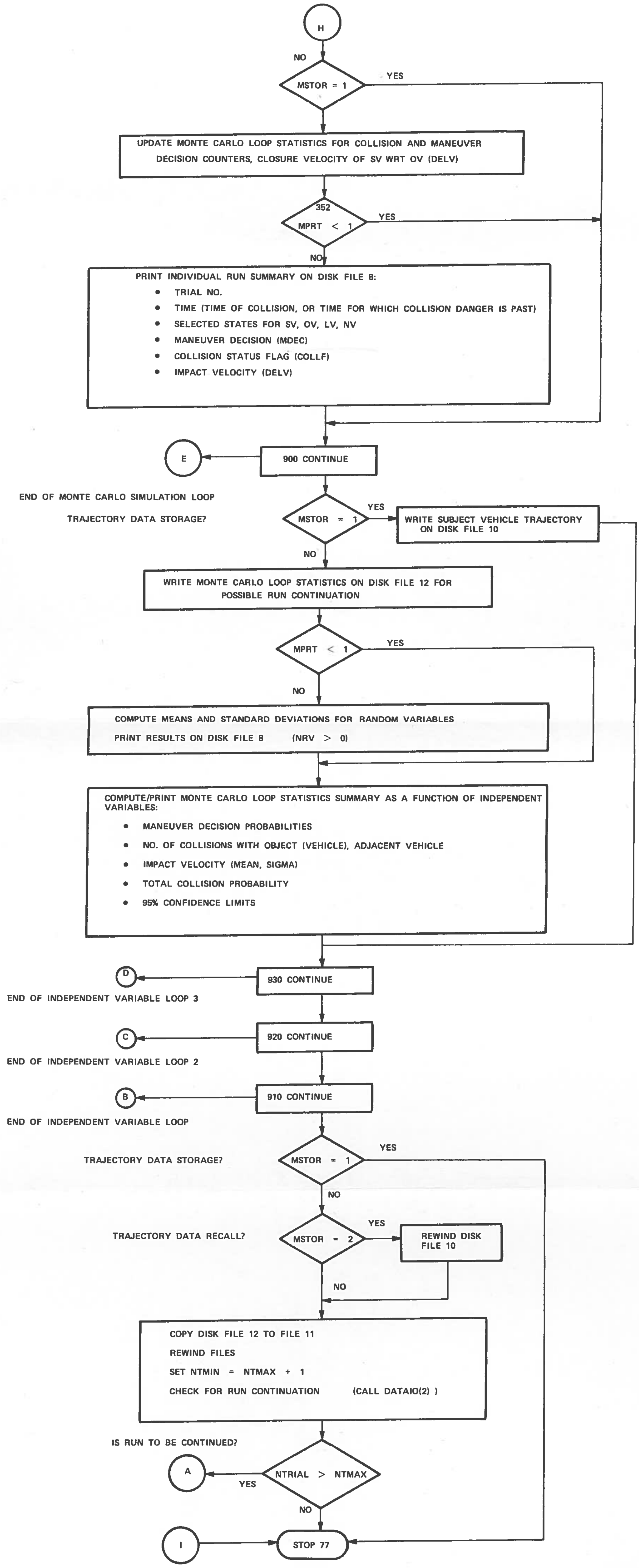


FIGURE A-1. MAIN PROGRAM FLOW CHART

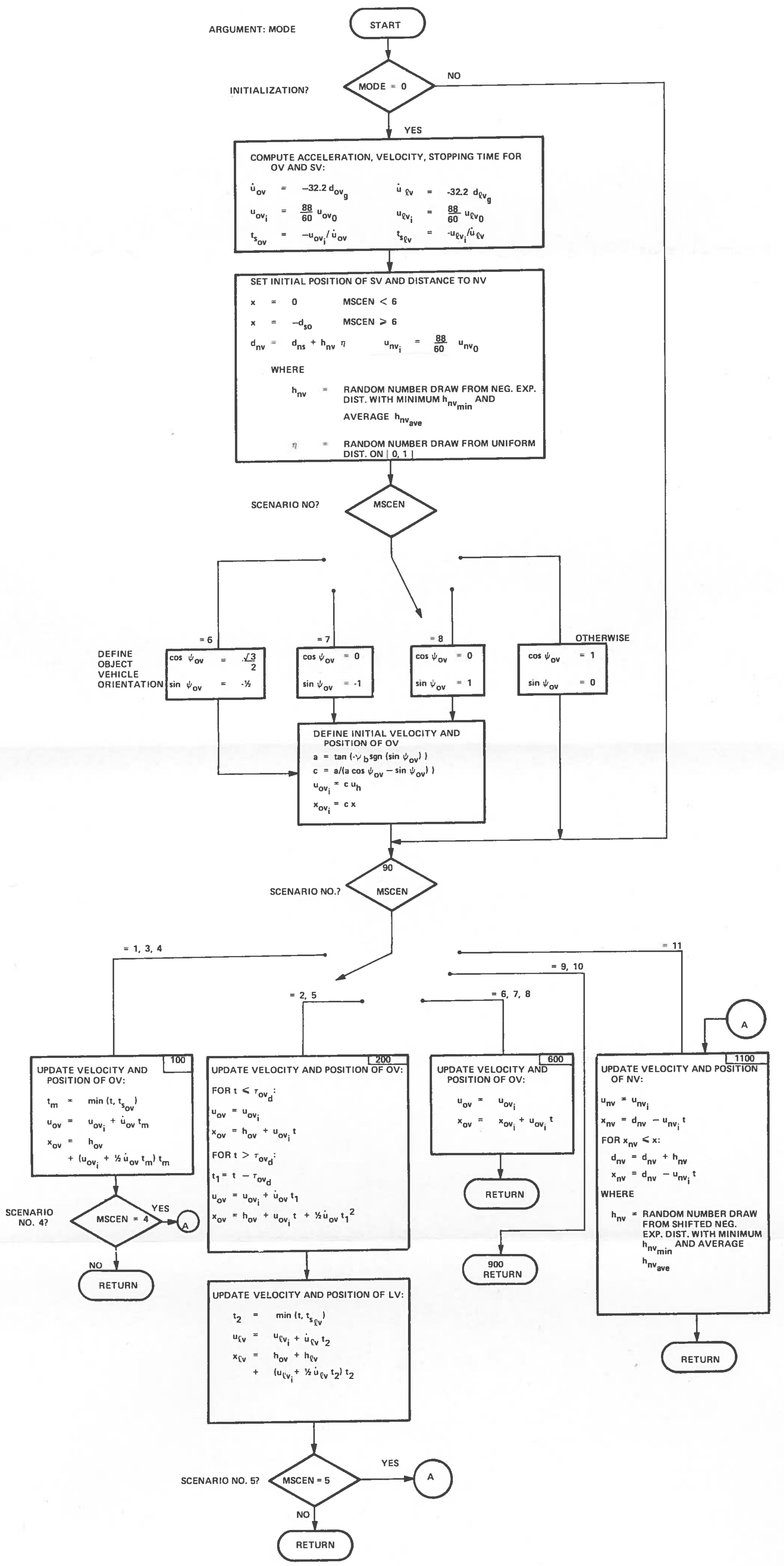


FIGURE A-2. SUBROUTINE SCEN FLOW CHART

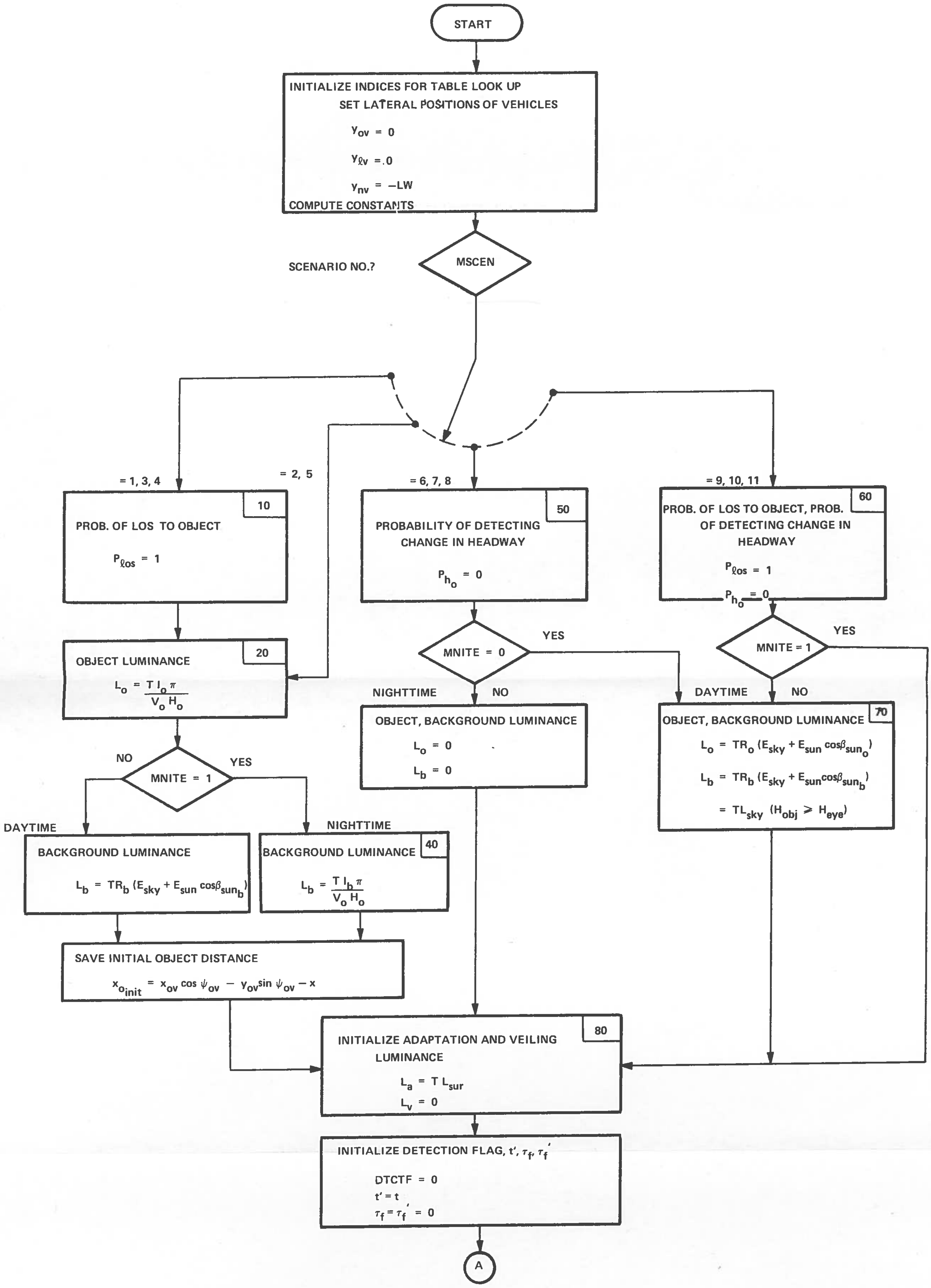


FIGURE A-3. SUBROUTINE DETECT FLOW CHART

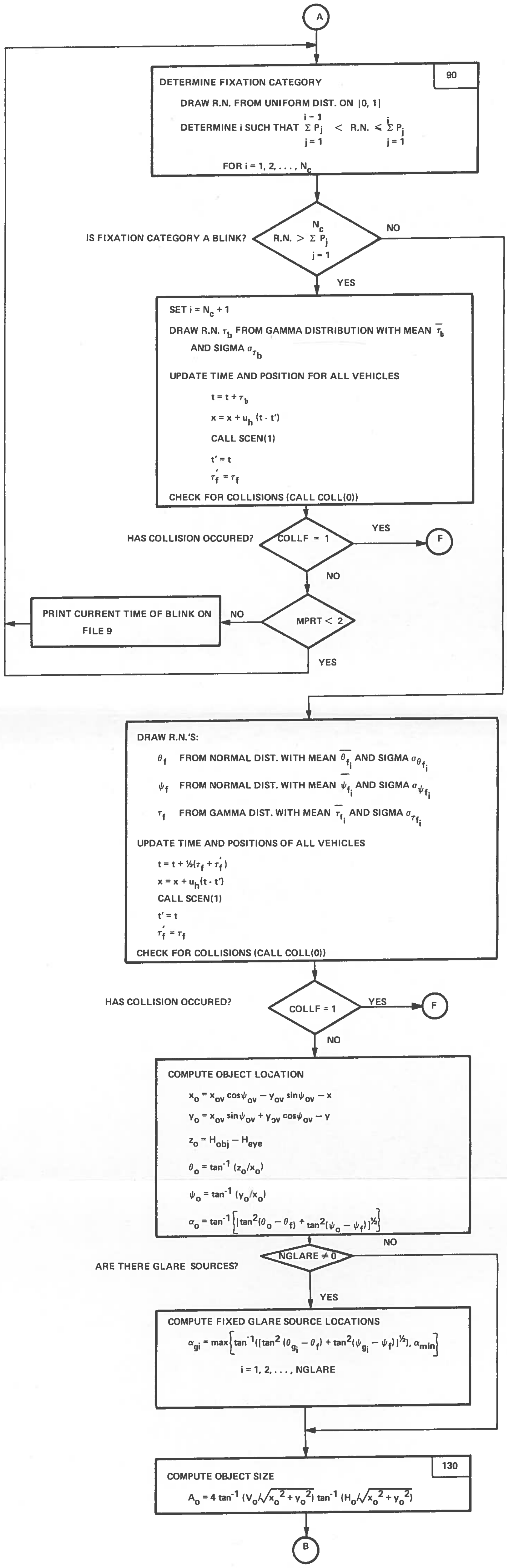


FIGURE A-3. SUBROUTINE DETECT FLOW CHART

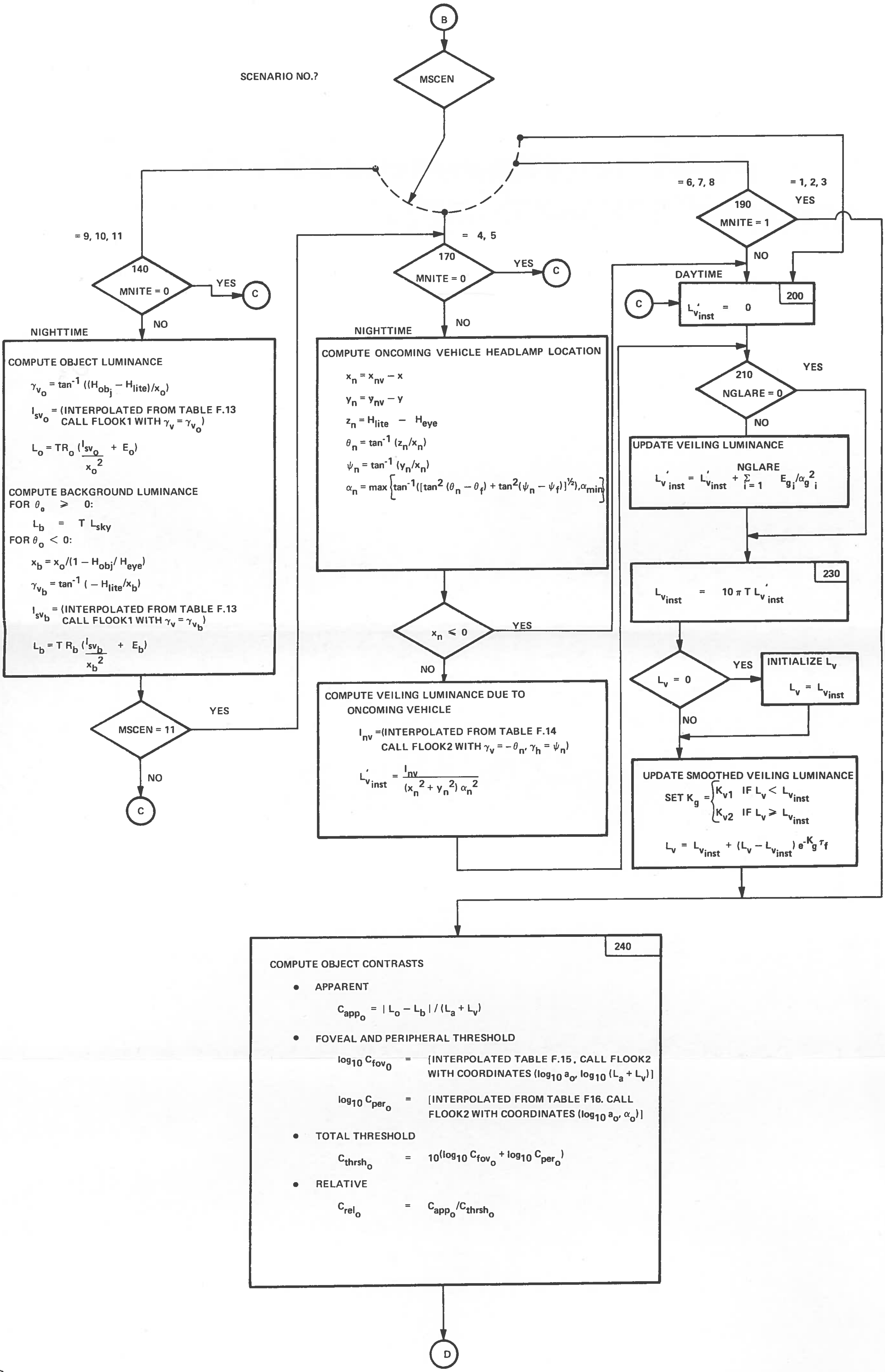


FIGURE A-3. SUBROUTINE DETECT FLOW CHART

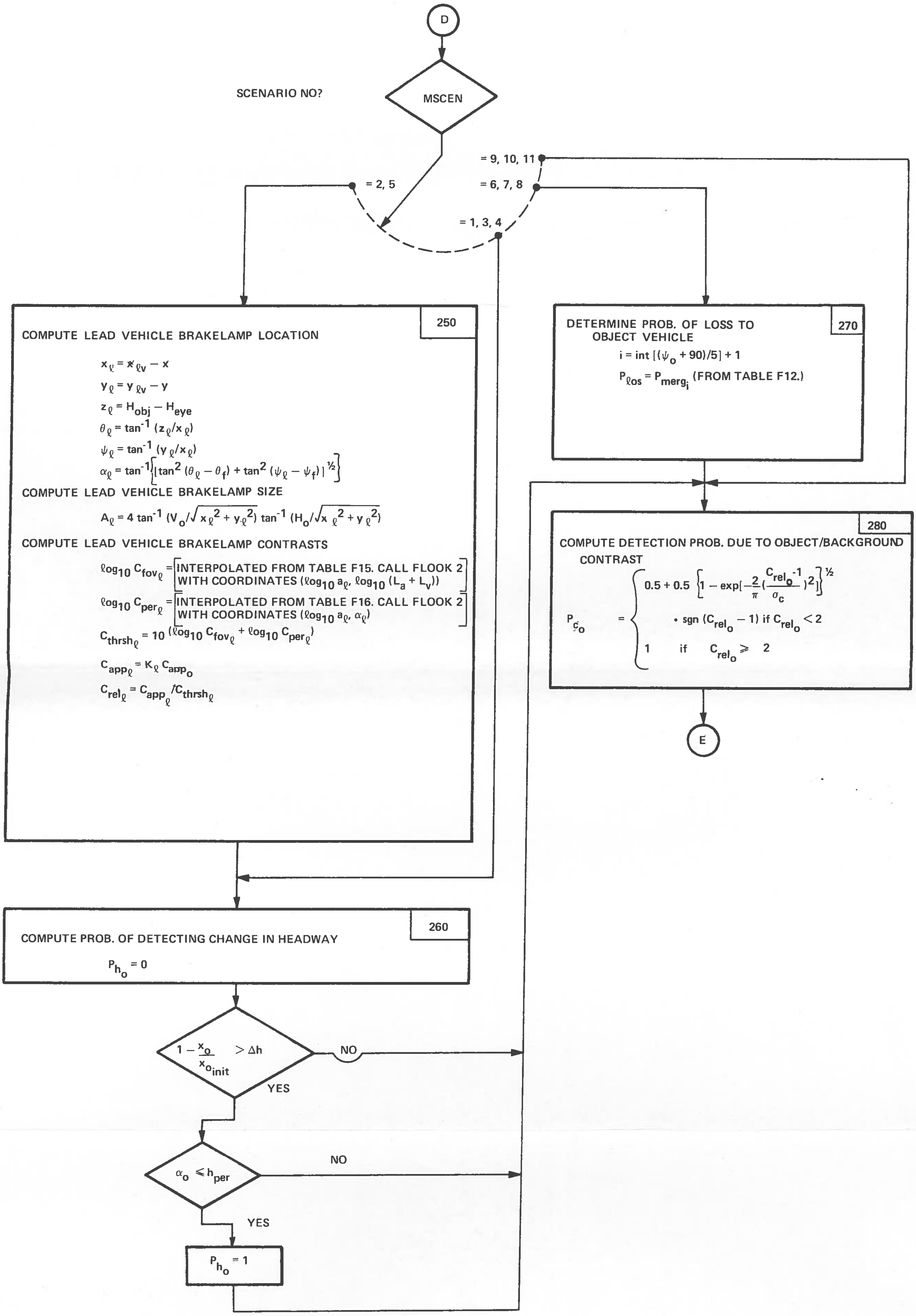


FIGURE A-3. SUBROUTINE DETECT FLOW CHART

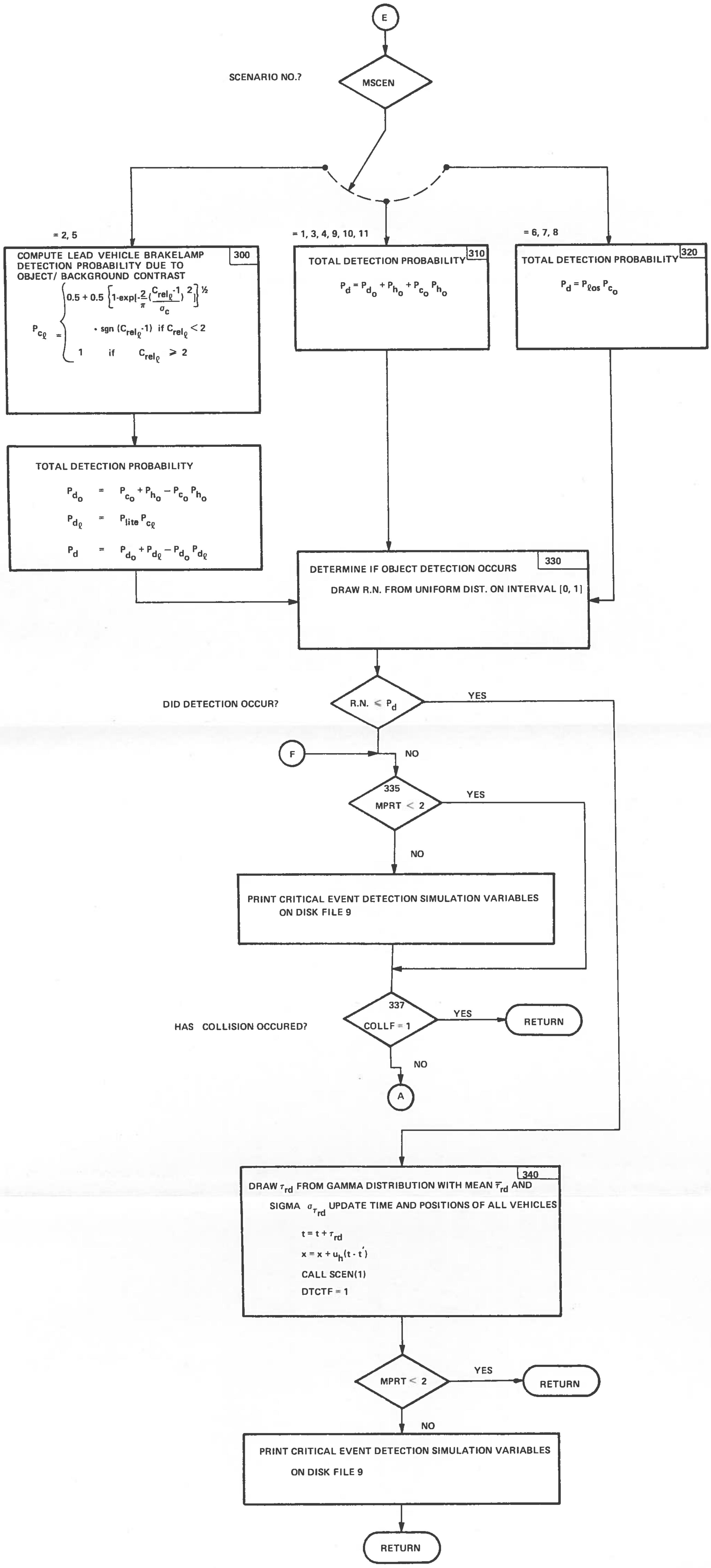


FIGURE A-3. SUBROUTINE DETECT FLOW CHART

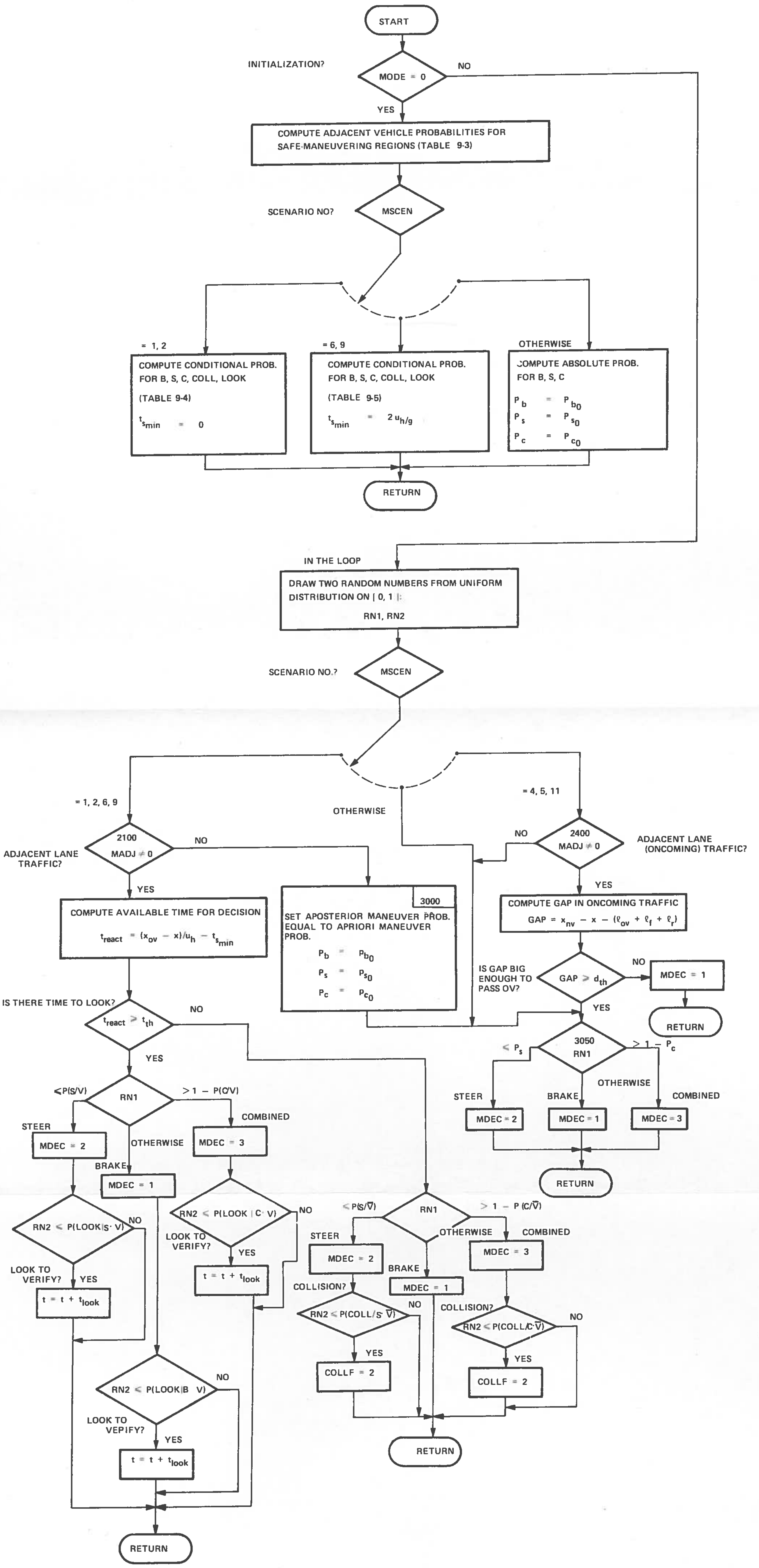


FIGURE A-4. SUBROUTINE DECISN FLOW CHART

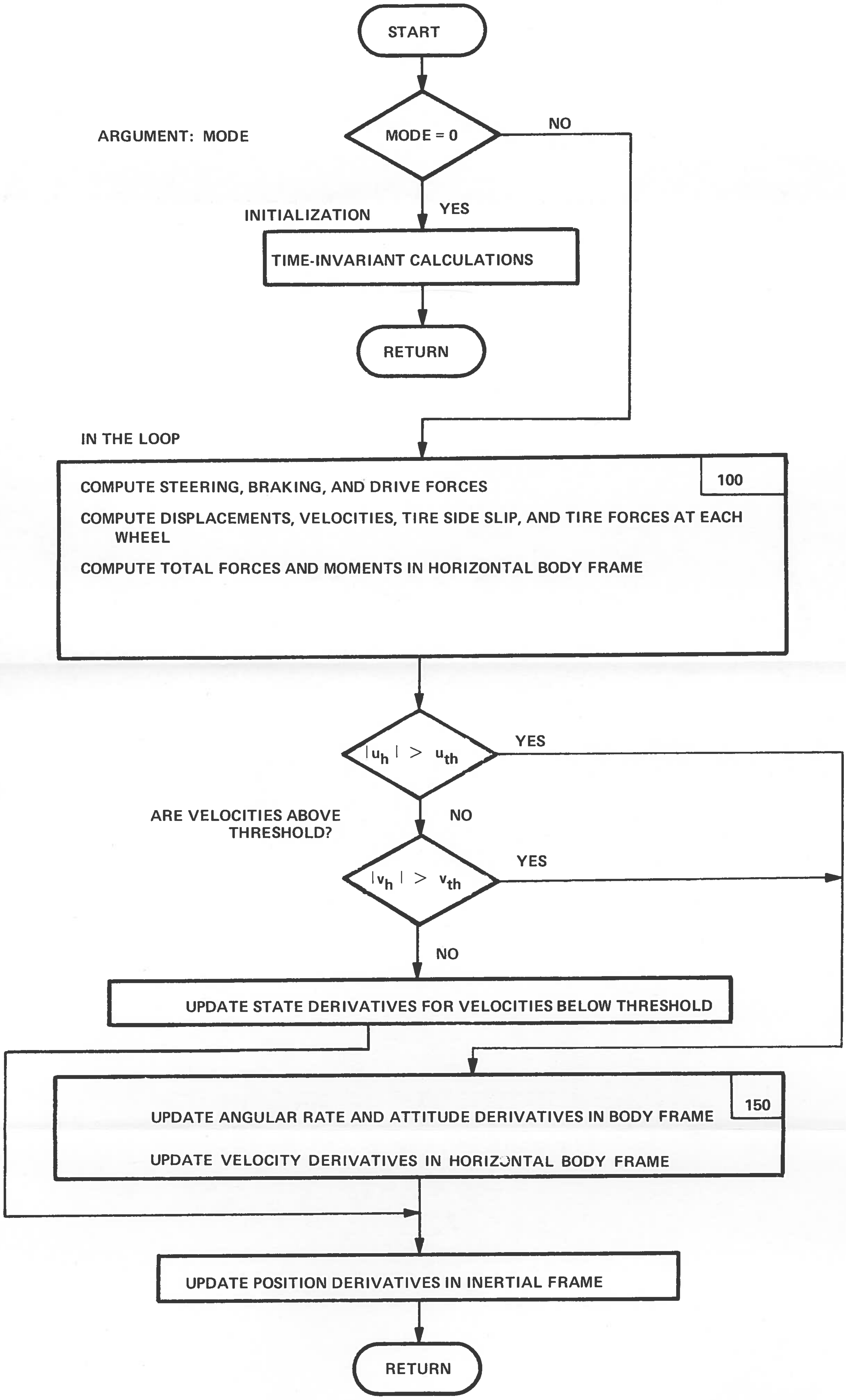


FIGURE A-5. SUBROUTINE VEH6 FLOW CHART (SEE APPENDIX D FOR EQUATIONS)

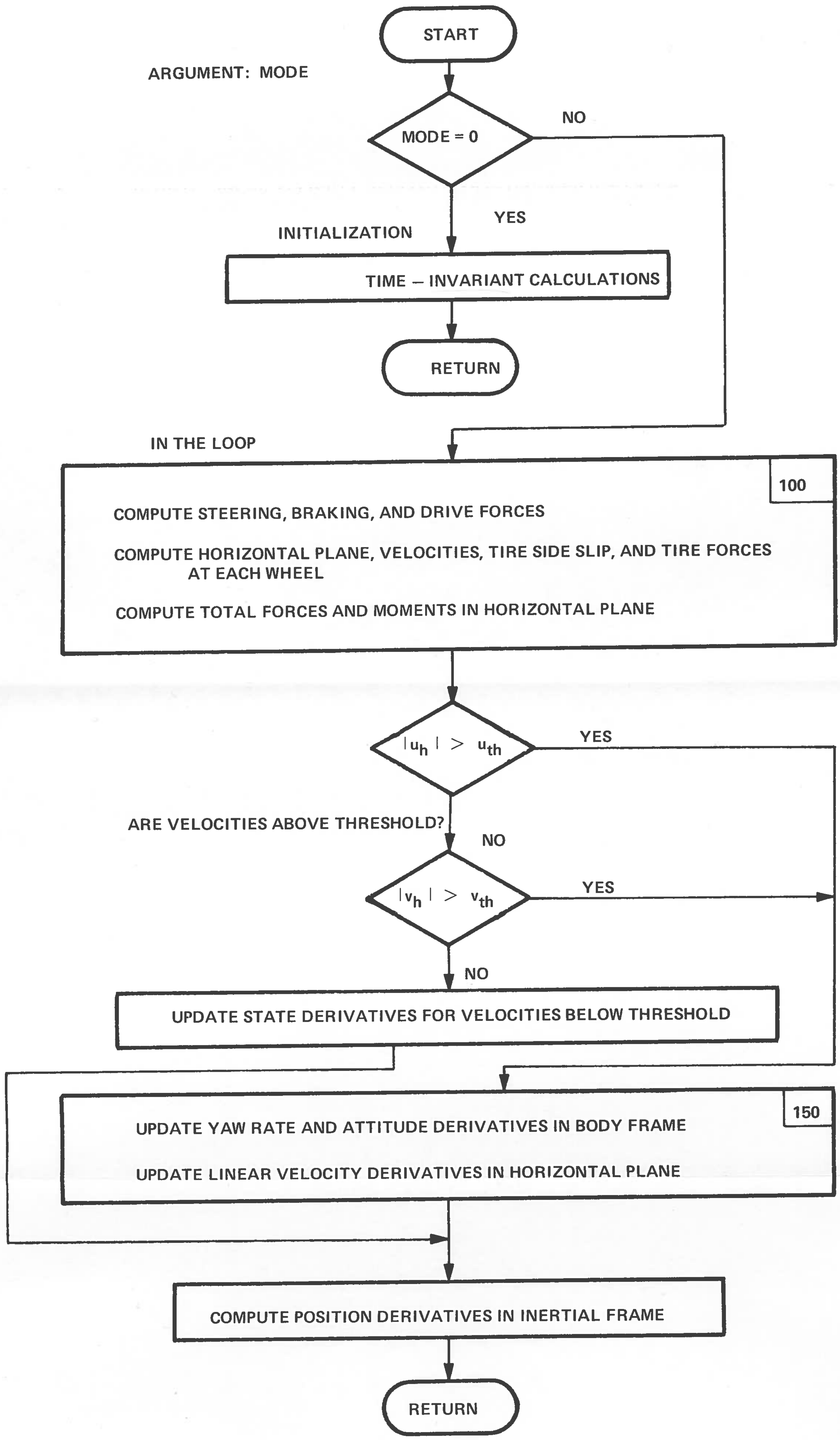


FIGURE A-6. SUBROUTINE VEH3 FLOW CHART (SEE APPENDIX D FOR EQUATIONS)

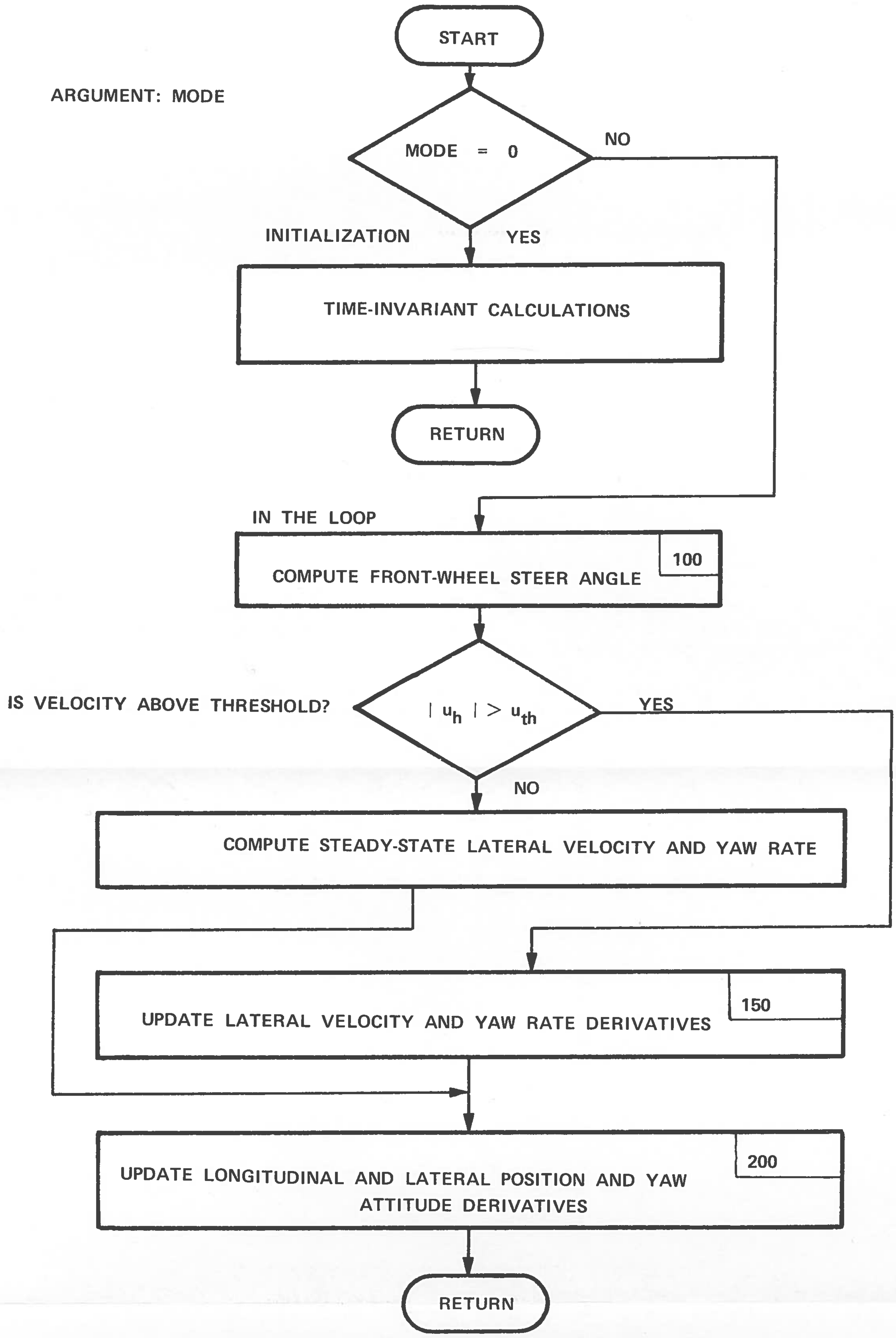


FIGURE A-7. SUBROUTINE VEH2 FLOW CHART (SEE APPENDIX D FOR EQUATIONS)

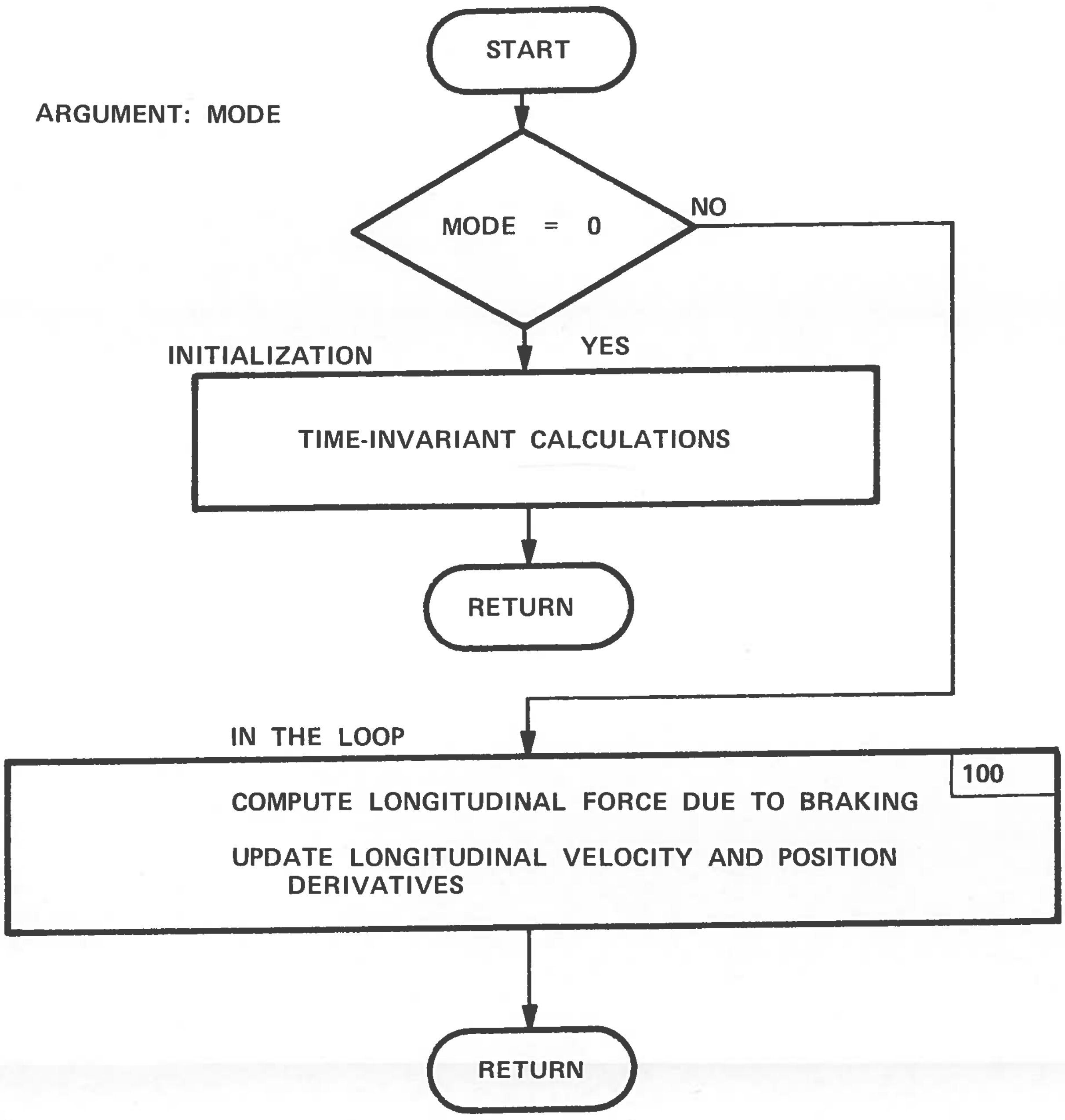


FIGURE A-8. SUBROUTINE VEH1 FLOW CHART (SEE APPENDIX D FOR EQUATIONS)

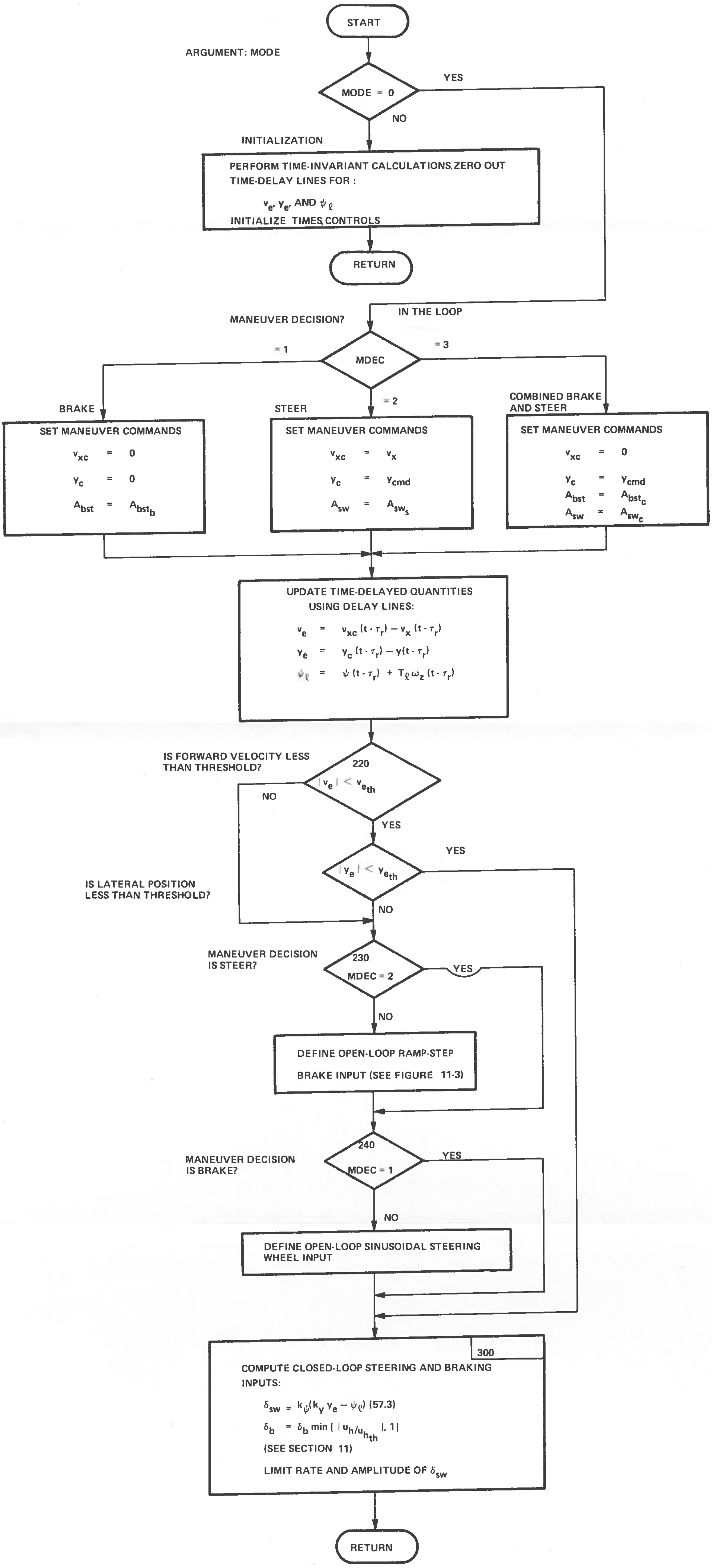


FIGURE A-9. SUBROUTINE DRIVER FLOW CHART

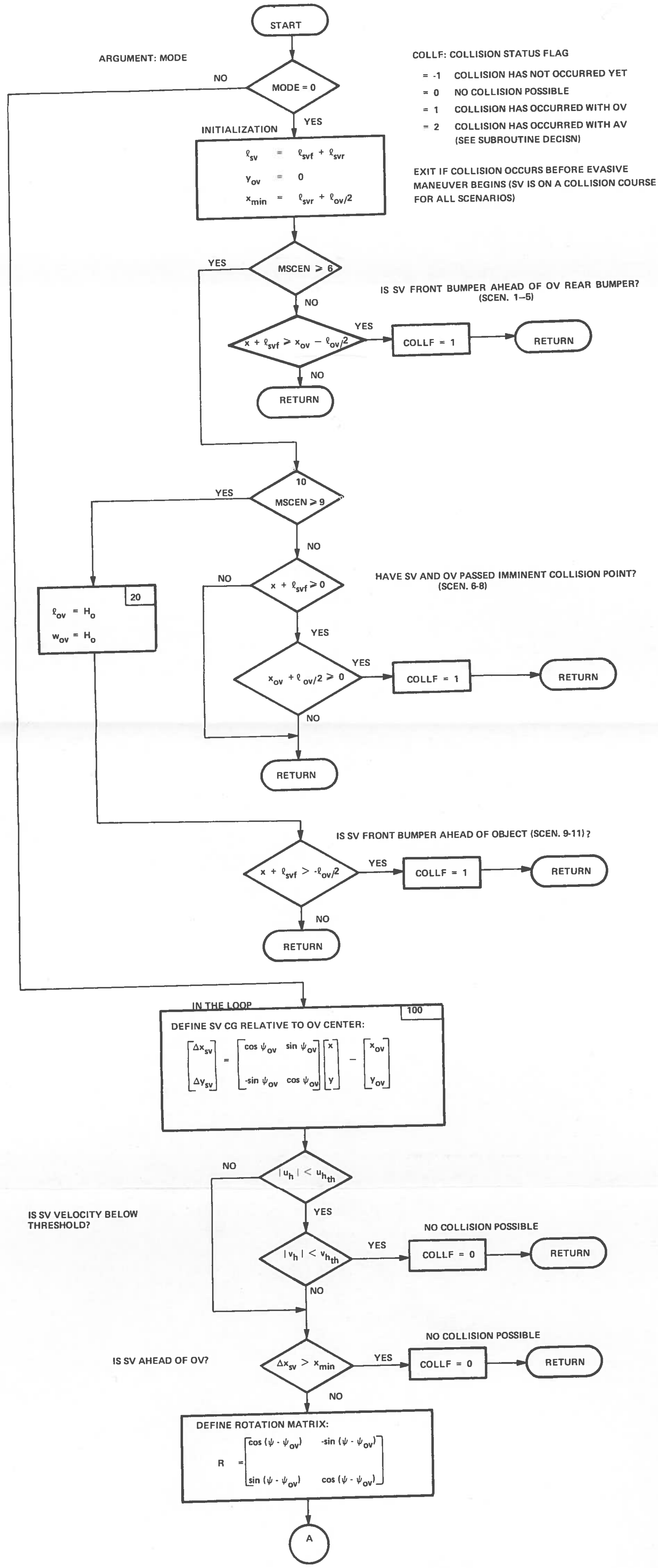


FIGURE A-10. SUBROUTINE COLL FLOW CHART

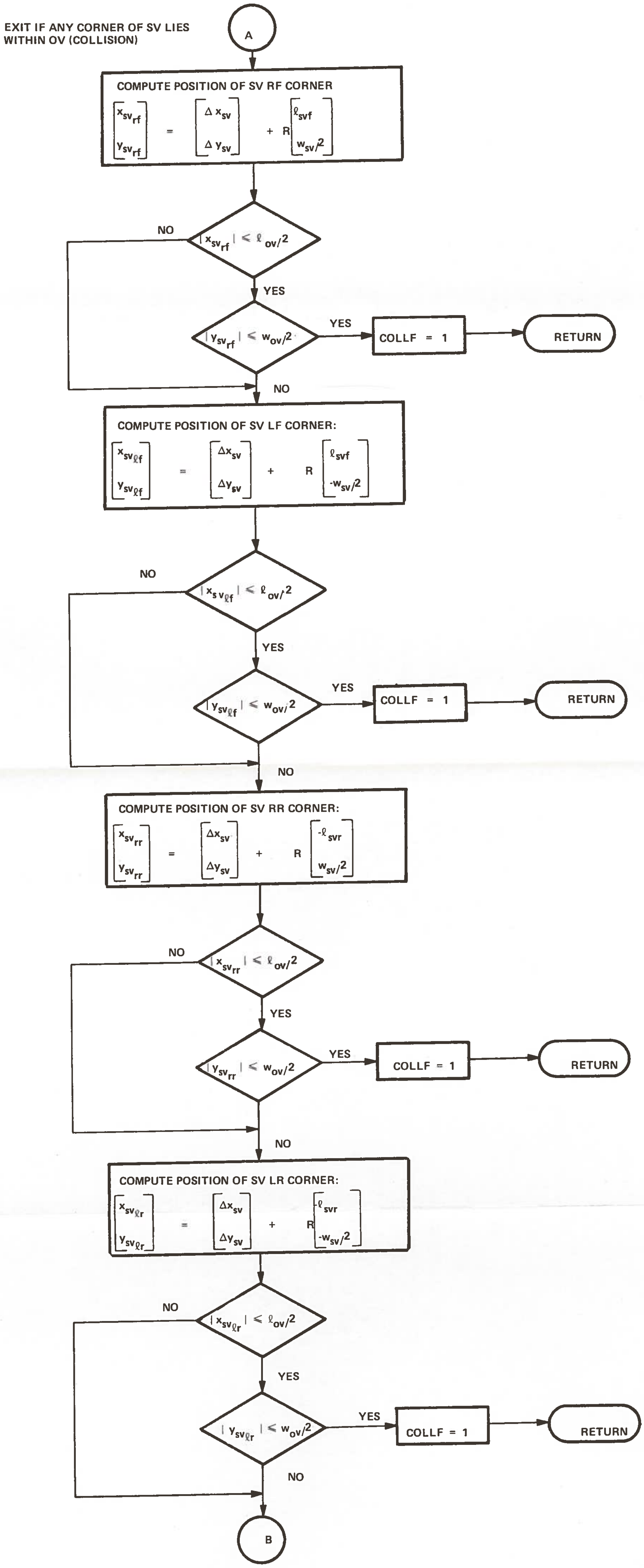


FIGURE A-10. SUBROUTINE COLL FLOW CHART

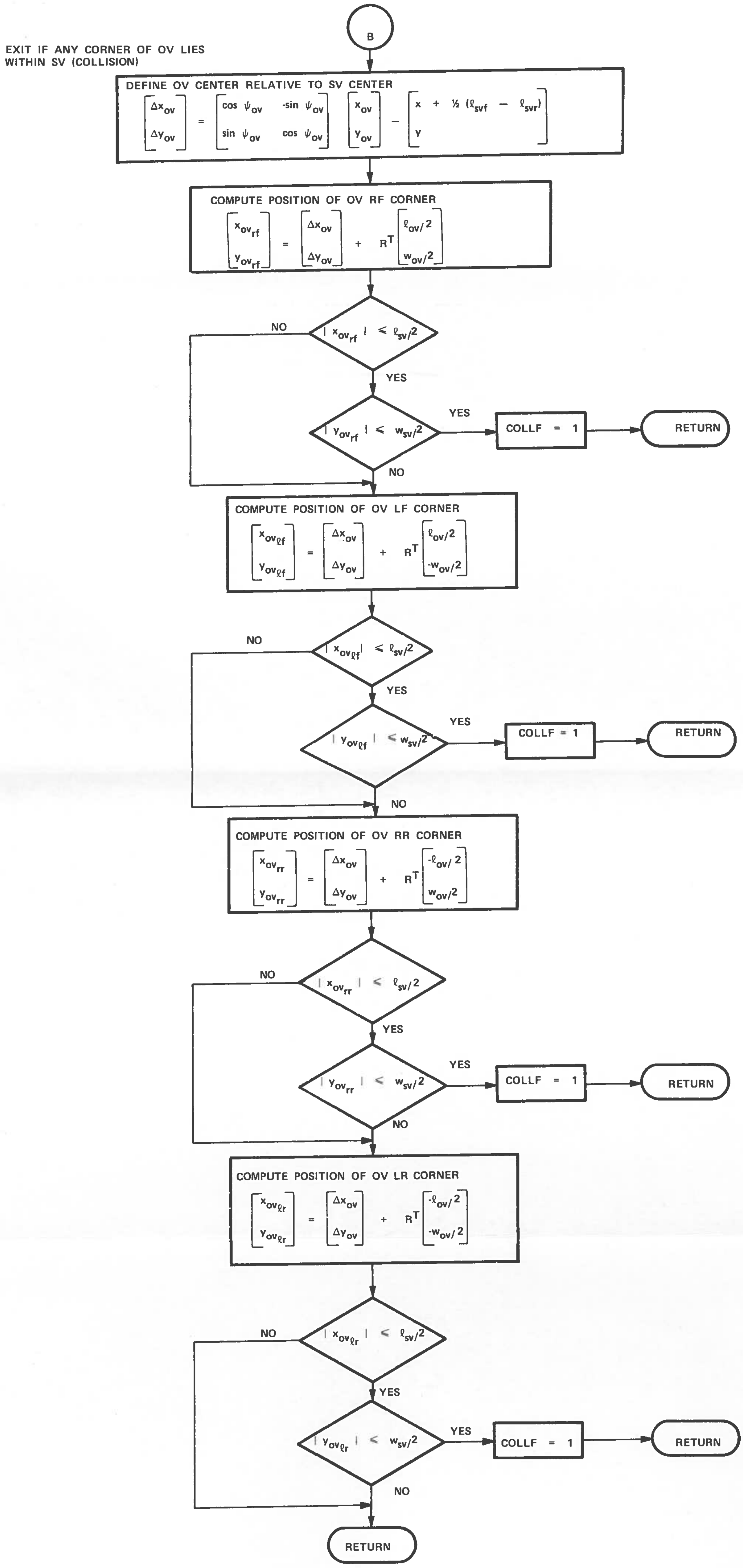


FIGURE A-10. SUBROUTINE COLL FLOW CHART

SUBROUTINE DATAIO FLOW CHART

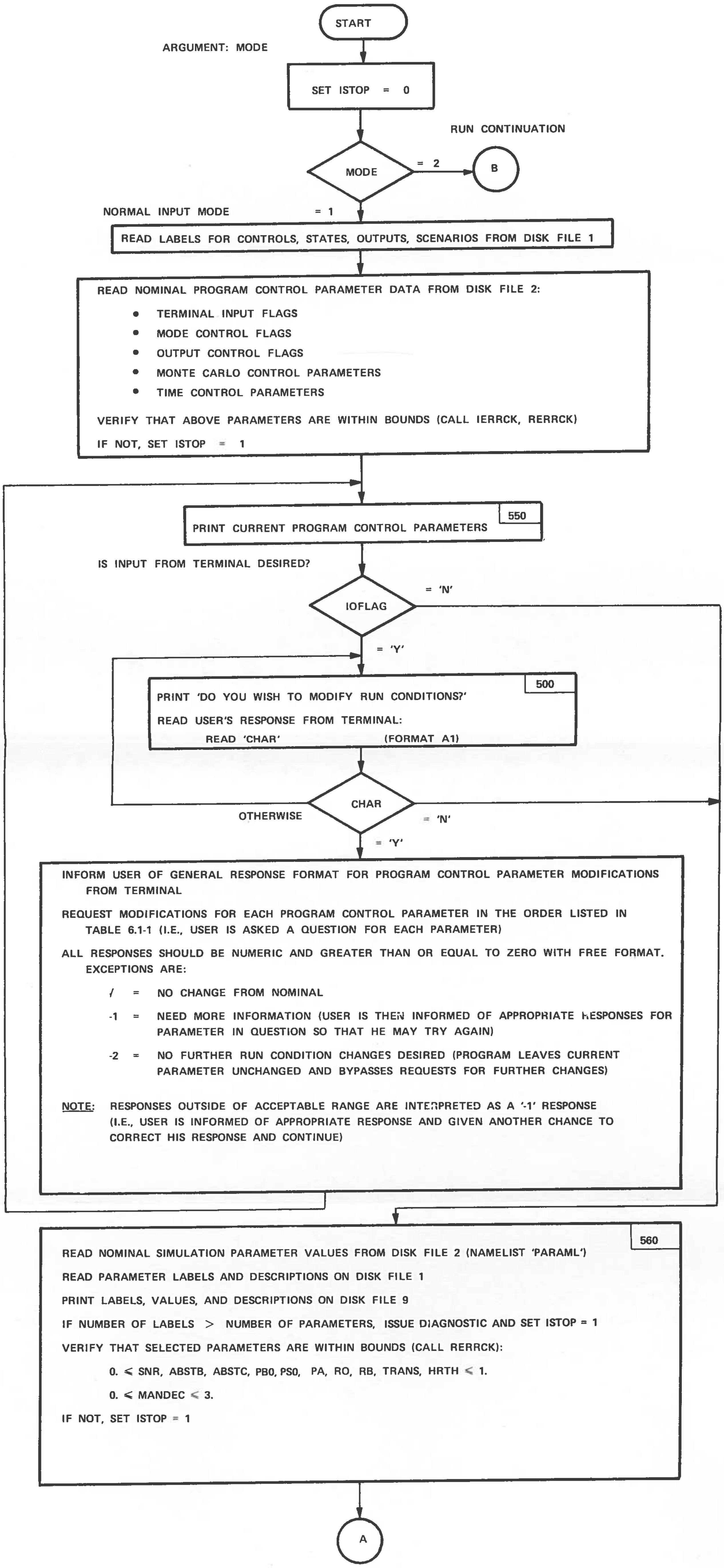


FIGURE A-11. SUBROUTINE DATAIO FLOW CHART

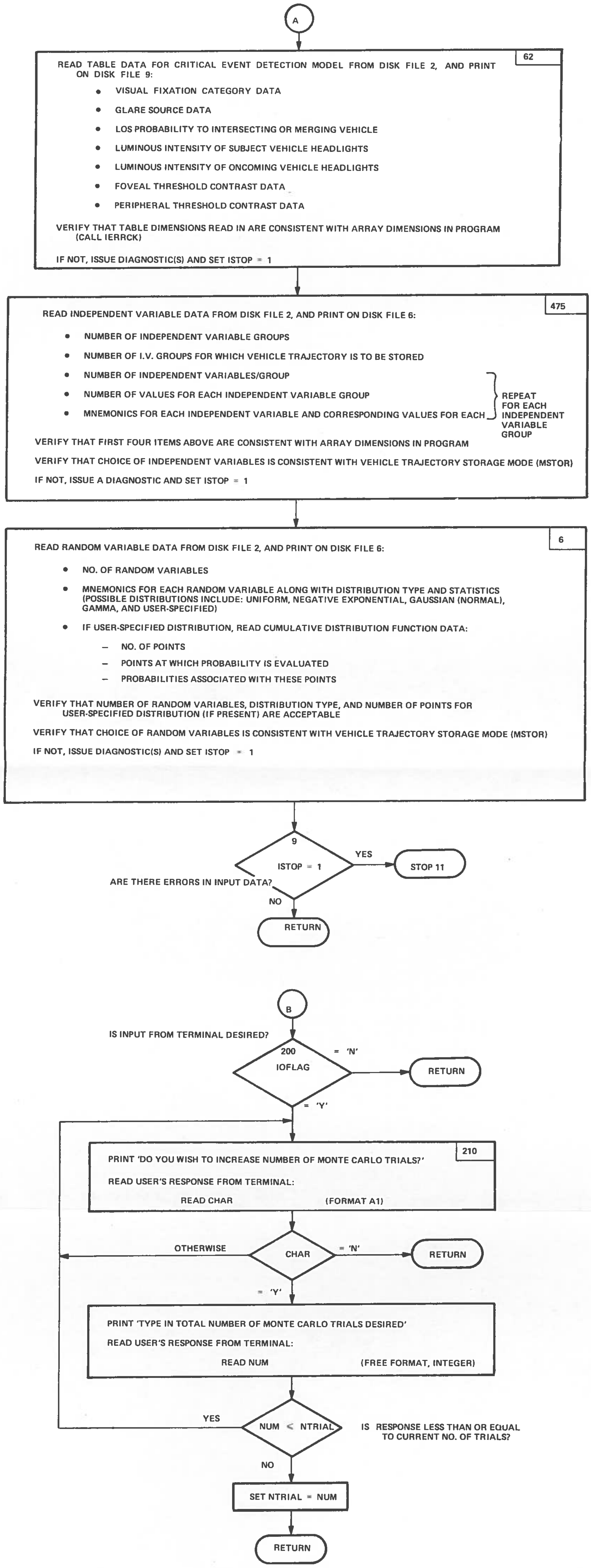


FIGURE A-11. SUBROUTINE DATAIO FLOW CHART

APPENDIX B

PROGRAM LISTINGS

LIST OF ILLUSTRATIONS

```
C PROGRAM MAIN
C
C FILE1 = LABEL INPUT DATA
C FILE2 = PARAMETER INPUT DATA
C FILE5 = TERMINAL INPUT DATA
C FILE6 = OVERALL RUN SUMMARY (NORMAL TERMINAL OUTPUT)
C FILE7 = OVERALL RUN SUMMARY (COPY OF TERMINAL OUTPUT)
C FILE8 = INDIVIDUAL MONTE CARLO RUN SUMMARIES
C FILE9 = INDIVIDUAL MONTE CARLO RUN TIME HISTORIES
C FILE10= SUBJECT VEHICLE TRAJECTORY DATA
C FILE11= MONTE CARLO RUN STATISTICS (INPUT)
C FILE12= MONTE CARLO RUN STATISTICS (OUTPUT)
C
      REAL IXX,IYY,IZZ,KF,KR,MUXF,MUXR,MUYF,MUYR,KSW,KBF,KBR,KSC
      REAL LW
      REAL LSVF,LSVR,LOV
      REAL IO,IB,LSKY,LSUR,KL,KV1,KV2
      REAL MPHFPS,MANDEC,LAV,LF,LR
      INTEGER COLLF,DTCTF
      REAL MASS
      REAL*8 LAB,LAB1,LAB2,LAB3,LABH,LABB(3),LABEL(80)
      REAL*8 LABX, LABU, LABY, LABP, BUFF, SCLAB
C
      DIMENSION XX(18),DX(18),U(2),DX1(18),TDATA(10),DATA(80,10)
      DIMENSION STOR(15,100)
      DIMENSION PAR(118),VAR(56),CMD(3),PMD(3)
      DIMENSION VAL(3)
C
      COMMON /INPUT/
     *    NIVG,NSTOR,NRV,L(3),NIV(3),NO(3),INDEX(50),NPT(50),
     *    IRV(50),IRVT(50),RV(50),RVMIN(50),RVMAX(50),
     *    RVS1(50),RVS2(50),PS(11,50),XS(11,50),PLIST(50,10),
     *    RVM(50),RVS(50),LABX(18),LABU(2),LABY(56),LABP(118),
     *    SCLAB(10,12),BUFF(10)
C
      COMMON /SCALES/ SFX(18)
C
      COMMON /STATES/
     1    UH,VH,WH,X,Y,Z,
     2    WX,WY,WZ,PHI,THE,PSI,
     3    UOV,XOV,ULV,XLV,UNV,XNV
C
      COMMON /DERIVS/
     1    UHD,VHD,WHD,XD,YD,ZD,
     2    WXD,WYD,WZD,PHID,THED,PSID,
     3    UOVD,XOVD,ULVD,XLVD,UNVD,XNVD
C
      COMMON /CONT/ DELSW,DELB
C
      COMMON /PARAM/
     1    UHO,VHO,WHO,XO,YO,ZO,
     2    WXO,WYO,WZO,PHIO,THEO,PSIO,
     3    WEIGHT,IXX,IYY,IZZ,
     4    DF,DR,TF,TR,ZF,ZR,HF,HR,
     5    KF,KR,CF,CR,
     6    MUXF,MUXR,MUYF,MUYR,BETASF,BETASR,SNR,
     7    KSW,KBF,KBR,
     8    KSC,UCMD,TDMAX,
     9    MANDEC,TAUR,TAUP,WC,VETH,YETH,
```

FIGURE B-1. <u>MAIN</u> PROGRAM LISTING

```
     A     ABR,ABSTB,ABSTC,ASWS,ASWC,TSW,SWMAX,SWRMAX,
     B     HOV,UOVO,DOVO,HLV,ULVO,DLVO,HNVMIN,HNVAVE,UNVO,DISTSO,DISTNS,
     C     PSIB,LW,TAUD,TAUOVD,
     D     LAV,HAVMIN,HAVAVE,LF,LR,PBO,PSO,PA,TTHRSH,DTHRSH,TLOOK,
     E     ESKY,ESUN,RO,EO,IO,BSUNO,RB,EB,IB,BSUNB,LSKY,LSUR,
     F     TRANS,KL,VO,HO,PLITE,HRTH,HPER,SIGC,KV1,KV2,ALPHMN,
     G     HEYE,HLITE,HOBJ,TAUBM,TAUBS,TAURDM,TAURDS,
     H     LSVF,LSVR,WSV,LOV,WOV,UHTH,VHTH
C
      COMMON
     *     MSCEN,MNITE,MDET,MADJ,MVEH,MSTOR,MPRT,
     *     NU,NX,NVAR,NTRIAL,ISEED,DT,DTPRT,DTSTOR,TMAX,
     *     DEGRAD,MPHFPS,G,TIME,MDEC,COLLF,DTCTF,CHDOV,SHDOV,CPSI,SPSI,
     *     FHX,FHY,FHZ,THX,THY,THZ,BETA,HEAD,VTOT,VX,VY,ATOT,AX,AY,
     1     UH1,VH1,WH1,Z1,FX1,FY1,FN1,BET1,FC1,FS1,
     2     UH2,VH2,WH2,Z2,FX2,FY2,FN2,BET2,FC2,FS2,
     3     UH3,VH3,WH3,Z3,FX3,FY3,FN3,BET3,FC3,FS3,
     4     UH4,VH4,WH4,Z4,FX4,FY4,FN4,BET4,FC4,FS4
C
      EQUIVALENCE (UHO,PAR(1)),(FHX,VAR(1))
      EQUIVALENCE (UH,XX(1)),(UHD,DX(1)),(DELSW,U(1))
      EQUIVALENCE (L1,L(1)),(L2,L(2)),(L3,L(3))
      EQUIVALENCE (LAB1,LABB(1)),(LAB2,LABB(2)),(LAB3,LABB(3))
      EQUIVALENCE (VALUE1,VAL(1)),(VALUE2,VAL(2)),(VALUE3,VAL(3))
C
      REAL*8 BLANK /1H /
      REAL*8 TEXT(2) / 5HTRIAL, 4HMDEC /
      INTEGER MINORD(3) / 1, 2, 3 /
C
 1030 FORMAT(///1X,23HOVERALL RUN SUMMARY FOR,I6,8H  TRIALS)
 1040 FORMAT(//33X9HNUMBER OF,6X6HIMPACT,6X11HPROBABILITY/
     *     7X22HMANEUVER PROBABILITIES,
     *     4X10HCOLLISIONS,4X8HVELOCITY,9X2HOF,10X10H95 PERCENT/
     *     8X21HBRAKE    STEER    COMB.,4X10HFWD.  LAT.,
     *     3X12HMEAN  ST DEV,3X9HCOLLISION,3X17HCONFIDENCE LIMITS//)
 1041 FORMAT(//3X11HINDEPENDENT,19X9HNUMBER OF,6X6HIMPACT,
     *     6X11HPROBABILITY/5X8HVARIABLE,6X22HMANEUVER PROBABILITIES,
     *     4X10HCOLLISIONS,4X8HVELOCITY,9X2HOF,10X10H95 PERCENT/
     *     7XA6,5X21HBRAKE    STEER    COMB.,4X10HFWD.  LAT.,
     *     3X12HMEAN  ST DEV,3X9HCOLLISION,3X17HCONFIDENCE LIMITS//)
 1042 FORMAT(//53X9HNUMBER OF,6X6HIMPACT,6X11HPROBABILITY/
     *     3X21HINDEPENDENT VARIABLES,3X22HMANEUVER PROBABILITIES,
     *     4X10HCOLLISIONS,4X8HVELOCITY,9X2HOF,10X10H95 PERCENT/
     *     3X,2(4X,A6),5X21HBRAKE    STEER    COMB.,4X10HFWD.  LAT.,
     *     3X12HMEAN  ST DEV,3X9HCOLLISION,3X17HCONFIDENCE LIMITS//)
 1043 FORMAT(//63X9HNUMBER OF,6X6HIMPACT,6X11HPROBABILITY/
     *     10X21HINDEPENDENT VARIABLES,6X22HMANEUVER PROBABILITIES,
     *     4X10HCOLLISIONS,4X8HVELOCITY,9X2HOF,10X10H95 PERCENT/
     *     3X,3(4X,A6),5X21HBRAKE    STEER    COMB.,4X10HFWD.  LAT.,
     *     3X12HMEAN  ST DEV,3X9HCOLLISION,3X17HCONFIDENCE LIMITS//)
 1070 FORMAT(/3(4X,A6,3H = ,F10.4))
 1110 FORMAT(/4XA6,3H = ,I6,3(4X,A6,3H = ,F10.4))
 1090 FORMAT(/3X,5HTRIAL,
     *     2X4HTIME,6X2HUH,6X2HVH,7X1HX,7X1HY,5X3HPSI,5X3HUOV,5X3HXOV,
     *     5X3HULV,5X3HXLV,5X3HUNV,5X3HXNV,2X4HMDEC,1X5HCOLLF,2X4HDELV/)
 1010 FORMAT(/1X,4HTIME,5X,10F11.3)
 1015 FORMAT(1X)
 1020 FORMAT(1X,A8,1X,10F11.3)
 1100 FORMAT(I6,12F8.2,2I5,F8.2)
 1080 FORMAT(/1X,4X2HRV,6X4HMEAN,5X5HSIGMA)
```

FIGURE B-1. (continued)

```
1085 FORMAT(1X,A6,2F10.4)
1060 FORMAT(5X,3F8.4,1X,2I6,2F8.2,F10.4,6X,
    *       1H(,F6.4,2H, ,F6.4,1H))
1061 FORMAT(3X,F10.4,2X,3F8.4,1X,2I6,2F8.2,F10.4,6X,
    *       1H(,F6.4,2H, ,F6.4,1H))
1062 FORMAT(3X,2F10.4,2X,3F8.4,1X,2I6,2F8.2,F10.4,6X,
    *       1H(,F6.4,2H, ,F6.4,1H))
1063 FORMAT(3X,3F10.4,2X,3F8.4,1X,2I6,2F8.2,F10.4,6X,
    *       1H(,F6.4,2H, ,F6.4,1H))
1150 FORMAT(/1X,119(1H*))
C
C INITIALIZE CONSTANTS
C
      MSAMP = 10
      DEGRAD = ATAN(1.0)/45.0
      MPHFPS = 88.0/60.0
      G = 32.2
      CALL ERRSET(208,0,-1,0,0,0)
C
C DEFINE SCALE FACTORS FOR STATE VECTOR I/O
C
      DO 15 I = 1,3
   15 SFX(I) = MPHFPS
      DO 16 I = 4,6
   16 SFX(I) = 1.0
      DO 20 I = 7, 12
   20 SFX(I) = DEGRAD
      SFX(13) = MPHFPS
      SFX(14) = 1.0
      SFX(15) = MPHFPS
      SFX(16) = 1.0
      SFX(17) = MPHFPS
      SFX(18) = 1.0
C
C READ IN PROGRAM DATA
C
      CALL DATAIO(1)
      WRITE(9,1150)
C
C INITIALIZE DT2, MASS, RANDOM NUMBER GENERATOR
C
      DT2 = DT/2.0
      MASS = WEIGHT/G
      SEED = RAND(-ISEED,0.0,0.0,0,0.0,0.0)
C
C DEFINE LABELS FOR CONTROLS, STATES, VEHICLE VARIABLES
C
      NXU = NX + NU
      IF(MPRT .LT. 2) GO TO 55
      IF(NU .EQ. 0 ) GO TO 55
      DO 25 I = 1, NU
   25 LABEL(I) = LABU(I)
      IF(NX .EQ. 0 ) GO TO 55
      DO 30 I = 1, NX
   30 LABEL(NU+I) = LABX(I)
      IF(NVAR .EQ. 0 ) GO TO 55
      DO 40 I = 1, NVAR
   40 LABEL(NXU+I) = LABY(I)
   55 CONTINUE
C
```

FIGURE B-1. (continued)

```
C INITIALIZE INDICES FOR INDEPENDENT VARIABLE LOOPS
C
      NIV1 = NIV(1)
      NIV2 = NIV(2)
      NIV3 = NIV(3)
      NO1 = NO(1)
      NO2 = NO(2)
      NO3 = NO(3)
C
      LAB1 = BLANK
      LAB2 = BLANK
      LAB3 = BLANK
      VALUE1 = 0.0
      VALUE2 = 0.0
      VALUE3 = 0.0
C
      NTMIN = 1
      NVPRT = NXU + NVAR
      IF(NTRIAL .EQ. 0) GO TO 77
C
    1 IF(MSTOR .EQ. 1) GO TO 2
      NREC = 0
      MDEC = MANDEC
      NTMAX = NTRIAL
      NIVGP = NIVG
      LABH = TEXT(1)
      GO TO 3
    2 NTMAX = 3
      NIVGP = NSTOR
      LABH = TEXT(2)
C
C*****START OF INDEPENDENT VARIABLE LOOP 1
C
    3 DO 910 L1 = 1, NO1
      IF(NO1 .LE. 1) GO TO 912
      K1 = 1
      LAB1 = LABP(INDEX(K1))
      VALUE1 = PLIST(K1,L1)
      DO 911 K = 1, NIV1
      K1 = K
  911 PAR(INDEX(K1)) = PLIST(K1,L1)
  912 CONTINUE
C
C*****START OF INDEPENDENT VARIABLE LOOP 2
C
      DO 920 L2 = 1, NO2
      IF(NO2 .LE. 1) GO TO 922
      K2 = NIV1 + 1
      LAB2 = LABP(INDEX(K2))
      VALUE2 = PLIST(K2,L2)
      DO 921 K = 1, NIV2
      K2 = NIV1 + K
  921 PAR(INDEX(K2)) = PLIST(K2,L2)
  922 CONTINUE
C
C*****START OF INDEPENDENT VARIABLE LOOP 3
C
      DO 930 L3 = 1, NO3
      IF(NO3 .LE. 1) GO TO 932
      K3 = NIV1 + NIV2 + 1
```

FIGURE B-1. (continued)

```
      LAB3 = LABP(INDEX(K3))
      VALUE3 = PLIST(K3,L3)
      DO 931 K = 1, NIV3
      K3 = NIV1 + NIV2 + K
  931 PAR(INDEX(K3)) = PLIST(K3,L3)
  932 CONTINUE
C
C INITIALIZE MANEUVER DECISION MODEL (MSTOR = 0 OR 2)
C
      IF(MSTOR .EQ. 1) GO TO 35
      CALL DECISN(0)
C
C PRINT HEADINGS FOR OVERALL RUN SUMMARIES (MSTOR = 0 OR 2)
C
      IF(L1*L2*L3 .NE. 1) GO TO 32
      WRITE(6,1030) NTRIAL
      WRITE(7,1030) NTRIAL
      IF(NIVG .GT. 0) GO TO 80
      WRITE(6,1040)
      WRITE(7,1040)
      GO TO 32
   80 GO TO (81, 82, 83), NIVG
   81 WRITE(6,1041) LAB1
      WRITE(7,1041) LAB1
      GO TO 32
   82 WRITE(6,1042) LAB1, LAB2
      WRITE(7,1042) LAB1, LAB2
      GO TO 32
   83 WRITE(6,1043) LAB1, LAB2, LAB3
      WRITE(7,1043) LAB1, LAB2, LAB3
C
C PRINT HEADINGS FOR INDIVDUAL RUN SUMMARIES (MPRT >= 1)
C
   32 IF(MPRT .LT. 1) GO TO 35
      IF(NIVG .EQ. 0) GO TO 35
      WRITE(8,1070) (LABB(I),VAL(I),I=1,NIVG)
      WRITE(8,1090)
C
C ZERO-OUT SUMMATIONS FOR MONTE CARLO LOOP STATISTICS CALCULATIONS
C
   35 NCOLL1 = 0
      NCOLL2 = 0
      DELVS1 = 0
      DELVS2 = 0
      DO 17 I = 1, 3
   17 CMD(I) = 0
      IF(NRV .EQ. 0) GO TO 14
      DO 13 I = 1, NRV
      RVS1(I) = 0
   13 RVS2(I) = 0
   14 CONTINUE
C
C RE-INITIALIZE SUMMATIONS TO CURRENT VALUES FROM DISK FILE 11 FOR RUN
C CONTINUATION (NTMIN > 1)
C
      IF(NTMIN .GT. 1) READ (11) NCOLL1,NCOLL2,DELVS1,DELVS2,
     1      CMD,RSV1,RSV2
C
C READ SUBJECT VEHICLE TRAJECTORY DATA FROM DISK FILE 10 (MSTOR = 2)
C
```

FIGURE B-1. (continued)

```
      IF(MSTOR .NE. 2) GO TO 38
      LL = 1
      IF(NSTOR .EQ. NIVG)  GO TO 37
      NSTOR1 = NSTOR + 1
      DO 36 I = NSTOR1, NIVG
   36 LL = LL*L(I)
   37 IF(LL .EQ. 1) READ (10) STOR
C
C*****START OF MONTE CARLO SIMULATION LOOP
C
   38 DO 900 NT = NTMIN, NTMAX
      IF(MSTOR .NE. 1) GO TO 33
      MDEC = NT
      GO TO 12
C
C DRAW VALUES FOR RANDOM VARIABLES AND UPDATE STATISTICS (NRV > 0)
C
   33 IF(NRV .EQ. 0) GO TO 12
      DO 11 I = 1, NRV
      RV(I) = RAND(IRVT(I),RVMIN(I),RVMAX(I),NPT(I),PS(1,I),XS(1,I))
      RVS1(I) = RVS1(I) + RV(I)
      RVS2(I) = RVS2(I) + RV(I)**2
      IP = IRV(I)
   11 PAR(IP) = RV(I)
C
C ZERO-OUT CONTROLS, STATES, DERIVATIVES
C
   12 TIME = 0.0
      COLLF = -1
      U(1) = 0.0
      U(2) = 0.0
      DO 18 I = 1,18
      XX(I) = 0.0
      DX(I) = 0.0
   18 DX1(I) = 0.0
C
C SET SUBJECT VEHICLE STATES TO INITIAL VALUES; SCALE TO NATURAL UNITS
      UH = UHO*SFX(1)
      VH = VHO*SFX(2)
      WH = WHO*SFX(3)
      X = XO*SFX(4)
      Y = YO*SFX(5)
      Z = ZO*SFX(6)
      WX = WXO*SFX(7)
      WY = WYO*SFX(8)
      WZ = WZO*SFX(9)
      PHI = PHIO*SFX(10)
      THE = THEO*SFX(11)
      PSI = PSIO*SFX(12)
C
C PRINT HEADINGS FOR INDIVIDUAL MONTE CARLO RUNS (MPRT = 2)
C
      IF(MPRT .LT. 2) GO TO 92
      IF(NIVGP .GT. 0) GO TO 91
      WRITE(9,1110) LABH, NT
      GO TO 92
   91 WRITE(9,1110) LABH, NT, (LABB(I),VAL(I),I=1,NIVGP)
C
C INITIALIZE SCENARIO (MSCEN > 0, MSTOR = 0 OR 2)
C
   92 IF(MSCEN .EQ. 0) GO TO 60
```

FIGURE B-1. (continued)

```
      X = 0.0
      IF(MSTOR .EQ. 1) GO TO 60
      CALL SCEN(0)
C
C SIMULATE DRIVER EVENT DETECTION PROCESS
C
      IF(MDET .NE. 0) GO TO 71
C
C     PURE TIME DELAY MODEL
      TIME = TIME + TAUD
      X = X + UH*TAUD
      CALL SCEN(1)
      GO TO 73
C
C     EVENT DETECTION MODEL
   71 CALL DETECT
C
C SIMULATE MANEUVER DECISION PROCESS; CHECK FOR COLLISIONS
C
   73 TIMEP = TIME
      CALL DECISN(1)
      X = X + UH*(TIME-TIMEP)
      CALL SCEN(1)
      CALL COLL(0)
C
C BYPASS SIMULATION LOOP IF COLLISION STATUS IS KNOWN
C
      IF(COLLF .NE. -1) GO TO 350
      IF(MSTOR .EQ. 2) GO TO 50
C
C INITIALIZE DRIVER MODEL AND APPROPRIATE VEHICLE MODEL (MVEH > 0)
C
   60 IF(MVEH .EQ. 0) GO TO 50
      IF(MDEC .NE. 0) CALL DRIVER(0)
      MVEHP = MAX0(MVEH,MINORD(MDEC))
      IF(MDEC .EQ. 1 .AND. MVEH .EQ. 2) MVEHP = 3
C
      GO TO (41, 42, 43, 46, 46, 46), MVEHP
   41 CALL VEH1(0)
      GO TO 50
   42 CALL VEH2(0)
      GO TO 50
   43 CALL VEH3(0)
      GO TO 50
   46 CALL VEH6(0)
C
C INITIALIZE COUNTERS, TIMEKEEPERS
C
   50 IEXIT = 0
      NSAMP = 0
      ISAMP = 0
      TIMEO = TIME
      TPRT  = TIME
      TSTOR = TIME
      TIMEP = TIME + DT2
      XSTOR = X
C
C*****START OF THE DRIVER/VEHICLE SIMULATION LOOP
C
  100 CONTINUE
C
```

FIGURE B-1. (continued)

```
C STORE/RECALL SUBJECT VEHICLE TRAJECTORY (MSTOR = 1/2)
C
      IF(MSTOR .EQ. 0) GO TO 121
      IF(TIMEP .LT. TSTOR) GO TO 121
      ISAMP = ISAMP + 1
      IF(ISAMP .GT. 100) GO TO 121
      II = 5*(MDEC - 1)
      GO TO (125, 126), MSTOR
  125 STOR(II+1,ISAMP) = UH
      STOR(II+2,ISAMP) = VH
      STOR(II+3,ISAMP) = X
      STOR(II+4,ISAMP) = Y
      STOR(II+5,ISAMP) = PSI
      GO TO 127
  126 UH =  STOR(II+1,ISAMP)
      VH =  STOR(II+2,ISAMP)
      X =   STOR(II+3,ISAMP) + XSTOR
      Y =   STOR(II+4,ISAMP)
      PSI = STOR(II+5,ISAMP)
  127 TSTOR = TSTOR + DTSTOR
  121 CONTINUE
C
C COMPUTE VEHICLE VELOCITY IN INERTIAL COORDINATES
C
      CPSI = COS(PSI)
      SPSI = SIN(PSI)
      VX = UH*CPSI - VH*SPSI
      VY = UH*SPSI + VH*CPSI
C
C UPDATE SCENARIO; CHECK FOR COLLISIONS; UPDATE DRIVER, VEHICLE MODELS
C
      IF(MSCEN .EQ. 0) GO TO 130
      IF(MSTOR .EQ. 1) GO TO 130
      CALL SCEN(1)
      CALL COLL(1)
      IF(MSTOR .EQ. 2) GO TO 160
C
  130 IF(MVEH .EQ. 0) GO TO 160
      IF(MDEC .NE. 0) CALL DRIVER(1)
      GO TO (151, 152, 153, 156, 156, 156), MVEHP
  151 CALL VEH1(1)
      GO TO 160
  152 CALL VEH2(1)
      GO TO 160
  153 CALL VEH3(1)
      GO TO 160
  156 CALL VEH6(1)
  160 CONTINUE
C
C SET EXIT FLAG IF COLLISION STATUS IS KNOWN OR TIME >= TMAX
C
      IF(COLLF .NE. -1) IEXIT = 1
      IF(TIMEP .GE. TMAX) IEXIT = 1
C
C SAMPLE VEHICLE TIME HISTORY FOR PRINTOUT (MPRT = 2, NVPRT > 0)
C
      IF(MPRT .LT. 2) GO TO 320
      IF(NVPRT .EQ. 0) GO TO 320
      IF(TIMEP .LT. TPRT) GO TO 150
      NSAMP = NSAMP + 1
```

FIGURE B-1. (continued)

```
      TDATA(NSAMP) = TIME
      IF(NU .EQ. 0) GO TO 112
      DO 109 I = 1, NU
  109 DATA(I,NSAMP) = U(I)
  112 IF(NX .EQ. 0) GO TO 114
      DO 110 I = 1,NX
  110 DATA(NU+I,NSAMP) = XX(I)/SFX(I)
  114 IF(NVAR .EQ. 0) GO TO 140
      AX = (CPSI*FHX - SPSI*FHY)/MASS
      AY = (SPSI*FHX + CPSI*FHY)/MASS
      BETA = ATAN(VH/AMAX1(ABS(UH),0.001))/DEGRAD
      HEAD = PSI/DEGRAD + BETA
      VTOT = SQRT(VX*VX + VY*VY)
      ATOT = SQRT(AX*AX + AY*AY)
      DO 120 I = 1,NVAR
  120 DATA(NXU+I,NSAMP) = VAR(I)
  140 TPRT = TPRT + DTPRT
C
C PRINT RESULTS ON FILE 9 WHEN SAMPLE BUFFER IS FULL OR EXIT FLAG IS SET
C
  150 IF(NSAMP .EQ. MSAMP) GO TO 300
      IF(IEXIT .EQ. 1) GO TO 300
      GO TO 320
C
  300 WRITE(9,1010) (TDATA(N),N=1,NSAMP)
      WRITE(9,1015)
      DO 310 I = 1, NVPRT
  310 WRITE(9,1020) LABEL(I),(DATA(I,N),N=1,NSAMP)
      WRITE(9,1015)
      NSAMP = 0
C
C EXIT DRIVER/VEHICLE SIMULATION LOOP IF EXIT FLAG IS SET
C
  320 IF(IEXIT .EQ. 1) GO TO 350
C
C INTEGRATE STATES AND UPDATE DERIVATIVES
C
      IF(MSTOR .EQ. 2) GO TO 210
      IF(TIME .NE. TIMEO) GO TO 195
      DO 190 I = 1, 12
  190 DX1(I) = DX(I)
  195 DO 200 I = 1, 12
      XX(I) = XX(I) + DT2*(3.0*DX(I) - DX1(I))
  200 DX1(I) = DX(I)
C
C UPDATE TIME FOR SIMULATED VEHICLE MODES (MSTOR = 0 OR 1)
C
      TIME = TIME + DT
      TIMEP = TIME + DT2
      GO TO 100
C
C UPDATE TIME FOR RECALLED VEHICLE TRAJECTORY MODE (MSTOR = 2)
C
  210 TIME = TIME + DTSTOR
      TIMEP = TIME + DT2
      GO TO 100
C
C*****END OF DRIVER/VEHICLE SIMULATION LOOP
C
C UPDATE MONTE CARLO LOOP STATISTICS FOR COLLISIONS, MANEUVERS,
C AND IMPACT VELOCITY (MSTOR  = 0 OR 2)
```

FIGURE B-1. (continued)

```
C
  350 IF(MPRT .EQ. 2) WRITE(9,1150)
      IF(MSTOR .EQ. 1) GO TO 900
      IF(COLLF .EQ. 1) NCOLL1 = NCOLL1 + 1
      IF(COLLF .EQ. 2) NCOLL2 = NCOLL2 + 2
      IF(MDEC .NE. 0) CMD(MDEC) = CMD(MDEC) + 1
      UHM = UH/MPHFPS
      VHM = VH/MPHFPS
      UOVM = UOV/MPHFPS
      ULVM = ULV/MPHFPS
      UNVM = UNV/MPHFPS
      PSID = PSI/DEGRAD
      DELV = 0
      IF(COLLF .NE. 1) GO TO 352
      DELVX = VX*CHDOV + VY*SHDOV - UOV
      DELVY =-VX*SHDOV + VY*CHDOV
      DELV = SQRT(DELVX**2 + DELVY**2)/MPHFPS
      DELVS1 = DELVS1 + DELV
      DELVS2 = DELVS2 + DELV**2
C
C PRINT INDIVIDUAL RUN SUMMARY ON DISK FILE 8 (MPRT >= 1,MSTOR = 0 OR 2)
C
  352 IF(MPRT .LT. 1) GO TO 900
      WRITE(8,1100) NT,
     2     TIME, UHM, VHM, X, Y, PSID, UOVM, XOV, ULVM, XLV, UNVM, XNV,
     3     MDEC, COLLF, DELV
C
  900 CONTINUE
C
C*****END OF MONTE CARLO SIMULATION LOOP
C
C WRITE SUBJECT VEHICLE TRAJECTORY DATA ON DISK FILE 10 (MSTOR = 1)
C
      IF(MSTOR .NE. 1) GO TO 905
      WRITE(10) STOR
      GO TO 906
C
C WRITE MONTE CARLO LOOP STAT. ON FILE 12 FOR POSSIBLE RUN CONTINUATION
C
  905 NREC = NREC + 1
      WRITE(12) NCOLL1,NCOLL2,DELVS1,DELVS2,CMD,RSV1,RSV2
C
C COMPUTE MEANS AND STANDARD DEVIATIONS FOR RANDOM VARIABLES AND
C PRINT RESULTS ON DISK FILE 8 (MPRT >= 1, NRV > 0)
C
      IF(MPRT .LT. 1) GO TO 895
      WRITE(8,1015)
      IF(NRV .EQ. 0) GO TO 894
      NTM1 = MAX0(NTRIAL-1,1)
      WRITE(8,1080)
      DO 890 I = 1, NRV
      RVM(I) = RVS1(I)/NTRIAL
      RVS(I) = SQRT(ABS((RVS2(I) - NTRIAL*RVM(I)**2)/NTM1))
      LAB = LABP(IRV(I))
  890 WRITE(8,1085) LAB, RVM(I), RVS(I)
  894 WRITE(8,1150)
  895 CONTINUE
C
C COMPUTE/PRINT MONTE CARLO LOOP STATISTICS SUMMARY
C
```

FIGURE B-1. (continued)

```
      NCOLL = NCOLL1 + NCOLL2
      NCM1 = MAXO(NCOLL1-1,1)
      DELVM = DELVS1/AMAXO(NCOLL1,1)
      DELVS = SQRT(ABS(DELVS2 - NCOLL1*DELVM**2)/NCM1)
      PCOLL = FLOAT(NCOLL)/NTRIAL
      CONL = 1.96
      T1 = CONL**2/NTRIAL
      T2 = 1.0/(1.0+T1)
      RAD = SQRT(1.0 + 4.0*PCOLL*(1.0-PCOLL)/T1)
      CONL1 = T2*(PCOLL + 0.5*T1*(1.0-RAD))
      CONL2 = T2*(PCOLL + 0.5*T1*(1.0+RAD))
      DO 880 I = 1, 3
  880 PMD(I) = CMD(I)/NTRIAL
C
      IF(NIVG .GT. 0) GO TO 870
      WRITE(6,1060) PMD,NCOLL1,NCOLL2,DELVM,DELVS,
     *      PCOLL,CONL1,CONL2
      WRITE(7,1060) PMD,NCOLL1,NCOLL2,DELVM,DELVS,
     *      PCOLL,CONL1,CONL2
      GO TO 906
  870 GO TO (871, 872, 873), NIVG
  871 WRITE(6,1061) VALUE1,PMD,NCOLL1,NCOLL2,DELVM,DELVS,
     *      PCOLL,CONL1,CONL2
      WRITE(7,1061) VALUE1,PMD,NCOLL1,NCOLL2,DELVM,DELVS,
     *      PCOLL,CONL1,CONL2
      GO TO 906
  872 WRITE(6,1062) VALUE1,VALUE2,PMD,NCOLL1,NCOLL2,DELVM,DELVS,
     *      PCOLL,CONL1,CONL2
      WRITE(7,1062) VALUE1,VALUE2,PMD,NCOLL1,NCOLL2,DELVM,DELVS,
     *      PCOLL,CONL1,CONL2
      GO TO 906
  873 WRITE(6,1063) VALUE1,VALUE2,VALUE3,PMD,NCOLL1,NCOLL2,DELVM,DELVS,
     *      PCOLL,CONL1,CONL2
      WRITE(7,1063) VALUE1,VALUE2,VALUE3,PMD,NCOLL1,NCOLL2,DELVM,DELVS,
     *      PCOLL,CONL1,CONL2
C
  906 CONTINUE
C
      IF(NIVG .LT. 3) GO TO 930
      WRITE(6,1015)
      WRITE(7,1015)
  930 CONTINUE
C
C*****END OF INDEPENDENT VARIABLE LOOP 3
C
      IF(NIVG .LT. 2) GO TO 920
      WRITE(6,1015)
      WRITE(7,1015)
  920 CONTINUE
C
C*****END OF INDEPENDENT VARIABLE LOOP 2
C
      IF(NIVG .LT. 1) GO TO 910
      WRITE(6,1015)
      WRITE(7,1015)
  910 CONTINUE
C
C*****END OF INDEPENDENT VARIABLE LOOP 1
C
C COPY DISK FILE 12 TO DISK FILE 11: CHECK FOR RUN CONTINUATION
```

FIGURE B-1. (continued)

```
C
      IF(MSTOR .EQ. 1) GO TO .77
      IF(MSTOR .EQ. 2) REWIND 10
      REWIND 11
      REWIND 12
      DO 400 I = 1, NREC
      READ (12) NCOLL1,NCOLL2,DELVS1,DELVS2,CMD,RSV1,RSV2
  400 WRITE(11) NCOLL1,NCOLL2,DELVS1,DELVS2,CMD,RSV1,RSV2
      REWIND 11
      REWIND 12
      NTMIN = NTMAX + 1
      CALL DATAIO(2)
      IF(NTRIAL .GT. NTMAX) GO TO 1
C
   77 STOP .77
      END
```

FIGURE B-1. (concluded)

```
      SUBROUTINE SCEN(MODE)
C
C     SCENARIO DEFINITION MODEL
C
      REAL IXX,IYY,IZZ,KF,KR,MUXF,MUXR,MUYF,MUYR,KSW,KBF,KBR,KSC
      REAL LW
      REAL LSVF,LSVR,LOV
      REAL IO,IB,LSKY,LSUR,KL,KV1,KV2
      REAL MPHFPS,MANDEC,LAV,LF,LR
      INTEGER COLLF,DTCTF
C
      COMMON /STATES/
     1      UH,VH,WH,X,Y,Z,
     2      WX,WY,WZ,PHI,THE,PSI,
     3      UOV,XOV,ULV,XLV,UNV,XNV
C
      COMMON /DERIVS/
     1      UHD,VHD,WHD,XD,YD,ZD,
     2      WXD,WYD,WZD,PHID,THED,PSID,
     3      UOVD,XOVD,ULVD,XLVD,UNVD,XNVD
C
      COMMON /CONT/ DELSW,DELB
C
      COMMON /PARAM/
     1      UHO,VHO,WHO,XO,YO,ZO,
     2      WXO,WYO,WZO,PHIO,THEO,PSIO,
     3      WEIGHT,IXX,IYY,IZZ,
     4      DF,DR,TF,TR,ZF,ZR,HF,HR,
     5      KF,KR,CF,CR,
     6      MUXF,MUXR,MUYF,MUYR,BETASF,BETASR,SNR,
     7      KSW,KBF,KBR,
     8      KSC,UCMD,TDMAX,
     9      MANDEC,TAUR,TAUP,WC,VETH,YETH,
     A      ABR,ABSTB,ABSTC,ASWS,ASWC,TSW,SWMAX,SWRMAX,
     B      HOV,UOVO,DOVG,HLV,ULVO,DLVG,HNVMIN,HNVAVE,UNVO,DISTSO,DISTNS,
     C      PSIB,LW,TAUD,TAUOVD,
     D      LAV,HAVMIN,HAVAVE,LF,LR,PBO,PSO,PA,TTHRSH,DTHRSH,TLOOK,
     E      ESKY,ESUN,RO,EO,IO,BSUNO,RB,EB,IB,BSUNB,LSKY,LSUR,
     F      TRANS,KL,VO,HO,PLITE,HRTH,HPER,SIGC,KV1,KV2,ALPHMN,
     G      HEYE,HLITE,HOBJ,TAUBM,TAUBS,TAURDM,TAURDS,
     H      LSVF,LSVR,WSV,LOV,WOV,UHTH,VHTH
C
      COMMON
     *      MSCEN,MNITE,MDET,MADJ,MVEH,MSTOR,MPRT,
     *      NU,NX,NVAR,NTRIAL,ISEED,DT,DTPRT,DTSTOR,TMAX,
     *      DEGRAD,MPHFPS,G,TIME,MDEC,COLLF,DTCTF,CHDOV,SHDOV,CPSI,SPSI,
     *      FHX,FHY,FHZ,THX,THY,THZ,BETA,HEAD,VTOT,VX,VY,ATOT,AX,AY,
     1      UH1,VH1,WH1,Z1,FX1,FY1,FN1,BET1,FC1,FS1,
     2      UH2,VH2,WH2,Z2,FX2,FY2,FN2,BET2,FC2,FS2,
     3      UH3,VH3,WH3,Z3,FX3,FY3,FN3,BET3,FC3,FS3,
     4      UH4,VH4,WH4,Z4,FX4,FY4,FN4,BET4,FC4,FS4
C
C SCENARIO  1: FOLLOWING: FREEWAY
C SCENARIO  2: FOLLOWING: FREEWAY: INTERVENING VEHICLE
C SCENARIO  3: FOLLOWING: FREEWAY ENTRANCE RAMP
C SCENARIO  4: FOLLOWING: URBAN STREET
C SCENARIO  5: FOLLOWING: URBAN STREET: INTERVENING VEHICLE
C SCENARIO  6: LATERALLY MOVING VEHICLE: FREEWAY ENTRANCE RAMP
C SCENARIO  7: LATERALLY MOVING VEHICLE: INTERSECTION: VEHICLE APPROACH
C                                                      FROM RIGHT
C SCENARIO  8: LATERALLY MOVING VEHICLE: INTERSECTION: VEHICLE APPROACH
```

FIGURE B-2. SUBROUTINE SCEN PROGRAM LISTING

```
C                                                                 FROM LEFT
C SCENARIO  9: OBJECT ON ROADWAY; PEDESTRIAN MOVES FROM CONCEALED
C        P                         POSITION
C SCENARIO 10: STATIONARY OBJECT ON ROADWAY
C SCENARIO 11: STATIONARY OBJECT ON ROADWAY; ONCOMING VEHICLE
C
      IF(MODE .NE. 0) GO TO 90
C
C*****INITIALIZATION*****
C
      UOVD = -DOVG*G
      UOVI = UOVO*MPHFPS
      TSOV = -UOVI/UOVD
      ULVD = -DLVG*G
      ULVI = ULVO*MPHFPS
      TSLV = -ULVI/ULVD
      X = 0
      IF(MSCEN .GE. 6) X = -DISTSO
      UNVI = UNVO*MPHFPS
      DIST = X + DISTNS
     1     + RAND(1,0.0,1.0,0,0.0,0.0)*RAND(2,HNVMIN,HNVAVE,0,0.0,0.0)
      UOV = 0
      XOV = 0
C
      CHDOV = 1.0
      SHDOV = 0.0
      TPSIB = 1.0E6
      IF(IABS(MSCEN-7) .GT. 1) GO TO 90
      ITEMP = MSCEN - 5
      GO TO (60, 70, 80), ITEMP
   60 HDOVR = -30.0*DEGRAD
      CHDOV = COS(HDOVR)
      SHDOV = SIN(HDOVR)
      GO TO 85
   70 CHDOV = 0.0
      SHDOV =-1.0
      GO TO 85
   80 CHDOV = 0.0
      SHDOV = 1.0
   85 IF(PSIB .NE. 90.0) TPSIB = TAN(SIGN(PSIB*DEGRAD,-SHDOV))
      COEFF = TPSIB/(TPSIB*CHDOV - SHDOV)
      UOVI = COEFF*UH
      XOVI = COEFF*X
C
C*****IN THE LOOP*****
C
C UPDATE VELOCITY AND POSITION OF OBJECT, LEAD, AND ONCOMING VEHICLES
C
C SCENARIO:    1   2   3   4   5   6   7   8   9  10  11
   90 GO TO (100,200,100,100,200,600,600,600,900,900,1100),MSCEN
C
C     SCENARIOS 1, 3, 4
  100 TIMEM = AMIN1(TSOV,TIME)
      UOV = UOVI + UOVD*TIMEM
      XOV = HOV + (UOVI + 0.5*UOVD*TIMEM)*TIMEM
      IF(MSCEN .EQ. 4) GO TO 1100
      RETURN
C
C     SCENARIOS 2, 5
  200 TIME1 = TIME - TAUOVD
      IF(TIME1 .GT. 0.0) GO TO 240
```

FIGURE B-2. (continued)

```
      UOV = UOVI
      XOV = HOV + UOVI*TIME
      GO TO 250
  240 TIME1 = AMIN1(TSOV,TIME1)
      UOV = UOVI + UOVD*TIME1
      XOV = HOV + UOVI*TAUOVD + (UOVI + 0.5*UOVD*TIME1)*TIME1
  250 TIME2 = AMIN1(TSLV,TIME)
      ULV = ULVI + ULVD*TIME2
      XLV = HOV + HLV + (ULVI + 0.5*ULVD*TIME2)*TIME2
      IF(MSCEN .EQ. 5) GO TO 1100
      RETURN
C
C     SCENARIOS 6, :
  600 UOV = UOVI
      XOV = XOVI + UOVI*TIME
      RETURN
C
C     SCENARIOS 9, 10
  900 RETURN
C
C     SCENARIO 11 (AND 4, 5)
 1100 UNV = UNVI
      XNV = DIST - UNVI*TIME
      IF(XNV - X .GT. 0.0) RETURN
      DIST = DIST + RAND(2,HNVMIN,HNVAVE,0,0.0,0.0)
      XNV = DIST - UNVI*TIME
      RETURN
      END
```

FIGURE B-2. (concluded)

```
      SUBROUTINE DETECT
C
C     CRITICAL EVENT DETECTION MODEL
C
      REAL IXX,IYY,IZZ,KF,KR,MUXF,MUXR,MUYF,MUYR,KSW,KBF,KBR,KSC
      REAL LW
      REAL LSVF,LSVR,LOV
      REAL IO,IB,LSKY,LSUR,KL,KV1,KV2
      REAL MPHFPS,MANDEC,LAV,LF,LR
      INTEGER COLLF,DTCTF
      REAL LO,LB,LA,LV,ISVO,ISVB,INV,LVI,LAPLV,M2DPI
C
      DIMENSION PCATC(10),AG(10)
C
      COMMON /STATES/
     1     UH,VH,WH,X,Y,Z,
     2     WX,WY,WZ,PHI,THE,PSI,
     3     UOV,XOV,ULV,XLV,UNV,XNV
C
      COMMON /DERIVS/
     1     UHD,VHD,WHD,XD,YD,ZD,
     2     WXD,WYD,WZD,PHID,THED,PSID,
     3     UOVD,XOVD,ULVD,XLVD,UNVD,XNVD
C
      COMMON /CONT/ DELSW,DELB
C
      COMMON /PARAM/
     1     UHO,VHO,WHO,XO,YO,ZO,
     2     WXO,WYO,WZO,PHIO,THEO,PSIO,
     3     WEIGHT,IXX,IYY,IZZ,
     4     DF,DR,TF,TR,ZF,ZR,HF,HR,
     5     KF,KR,CF,CR,
     6     MUXF,MUXR,MUYF,MUYR,BETASF,BETASR,SNR,
     7     KSW,KBF,KBR,
     8     KSC,UCMD,TDMAX,
     9     MANDEC,TAUR,TAUP,WC,VETH,YETH,
     A     ABR,ABSTB,ABSTC,ASWS,ASWC,TSW,SWMAX,SWRMAX,
     B     HOV,UOVO,DOVG,HLV,ULVO,DLVG,HNVMIN,HNVAVE,UNVO,DISTSO,DISTNS,
     C     PSIB,LW,TAUD,TAUOVD,
     D     LAV,HAVMIN,HAVAVE,LF,LR,PBO,PSO,PA,TTHRSH,DTHRSH,TLOOK,
     E     ESKY,ESUN,RO,EO,IO,BSUNO,RB,EB,IB,BSUNB,LSKY,LSUR,
     F     TRANS,KL,VO,HO,PLITE,HRTH,HPER,SIGC,KV1,KV2,ALPHMN,
     G     HEYE,HLITE,HOBJ,TAUBM,TAUBS,TAURDM,TAURDS,
     H     LSVF,LSVR,WSV,LOV,WOV,UHTH,VHTH
C
      COMMON
     *     MSCEN,MNITE,MDET,MADJ,MVEH,MSTOR,MPRT,
     *     NU,NX,NVAR,NTRIAL,ISEED,DT,DTPRT,DTSTOR,TMAX,
     *     DEGRAD,MPHFPS,G,TIME,MDEC,COLLF,DTCTF,CHDOV,SHDOV,CPSI,SPSI,
     *     FHX,FHY,FHZ,THX,THY,THZ,BETA,HEAD,VTOT,VX,VY,ATOT,AX,AY,
     1     UH1,VH1,WH1,Z1,FX1,FY1,FN1,BET1,FC1,FS1,
     2     UH2,VH2,WH2,Z2,FX2,FY2,FN2,BET2,FC2,FS2,
     3     UH3,VH3,WH3,Z3,FX3,FY3,FN3,BET3,FC3,FS3,
     4     UH4,VH4,WH4,Z4,FX4,FY4,FN4,BET4,FC4,FS4
C
      COMMON /TABLE/
     1     NCAT,NGLARE,NMERG,NPTD,NPTXE,NPTYE,NPTXF,NPTYF,NPTXG,NPTYG,
     2     PCAT(10),THFM(10),THFS(10),PSFM(10),PSFS(10),TAUFM(10),
     3     TAUFS(10),EG(10),THG(10),PSG(10),PMERG(36),YID(20),FYD(20),
     4     XIE(20),YIE(10),FXYE(20,10),XIF(10),YIF(10),FXYF(10,10),
     5     XIG(10),YIG(30),FXYG(10,30)
```

FIGURE B-3. SUBROUTINE DETECT PROGRAM LISTING

```
C
 1000   FORMAT(/2X5HTIME ,F5.2/
     *     2X2HIC,I9,2X5HDTCTF,I6,2X2HX ,F9.2,2X3HTHF,F8.2,2X3HPSF,F8.2,
     *     2X5HTAUF ,F6.2,2X4HPLOS,F7.2,          13X,2X2HLA,F9.3/
     *     2X2HXO,F9.2,2X2HYO,F9.2,2X2HZO,F9.2,2X3HTHO,F8.2,2X3HPSO,F8.2,
     *     2X5HALPHO,F6.2,2X3HGVO,F8.2,2X4HISVO,F7.0,2X2HLO,F9.3/
     *     2X2HXL,F9.2,2X2HYL,F9.2,2X2HZL,F9.2,2X3HTHL,F8.2,2X3HPSL,F8.2,
     *     2X5HALPHL,F6.2,2X3HGVB,F8.2,2X4HISVB,F7.0,2X2HLB,F9.3/
     *     2X2HXN,F9.2,2X2HYN,F9.2,2X2HZN,F9.2,2X3HTHN,F8.2,2X3HPSN,F8.2,
     *     2X5HALPHN,F6.2,          13X,2X4HINV ,F7.0,2X2HLV,F9.3/
     *     2X5HAREAO,F6.3,2X5HCAPPO,F6.2,2X5HCFOVO,F6.2,2X5HCPERO,F6.2,
     *     2X5HCTHO ,F6.2,2X5HCRELO,F6.2,2X3HPDO,F8.2,2X3HPCO,F8.2,
     *     2X3HPHO,F8.2/
     *     2X5HAREAL,F6.3,2X5HCAPPL,F6.2,2X5HCFOVL,F6.2,2X5HCPERL,F6.2,
     *     2X5HCTHL ,F6.2,2X5HCRELL,F6.2,2X3HPDL,F8.2,2X3HPCL,F8.2,
     *     2X3HPD ,F8.2)
 1010   FORMAT(/2X,5HTIME ,F5.2,9H  (BLINK))
C
C SCENARIO  1: FOLLOWING: FREEWAY
C SCENARIO  2: FOLLOWING: FREEWAY: INTERVENING VEHICLE
C SCENARIO  3: FOLLOWING: FREEWAY ENTRANCE RAMP
C SCENARIO  4: FOLLOWING: URBAN STREET
C SCENARIO  5: FOLLOWING: URBAN STREET: INTERVENING VEHICLE
C SCENARIO  6: LATERALLY MOVING VEHICLE: FREEWAY ENTRANCE RAMP
C SCENARIO  7: LATERALLY MOVING VEHICLE: INTERSECTION: VEHICLE APPROACH
C                                                      FROM RIGHT
C SCENARIO  8: LATERALLY MOVING VEHICLE: INTERSECTION: VEHICLE APPROACH
C                                                      FROM LEFT
C SCENARIO  9: OBJECT ON ROADWAY: PEDESTRIAN MOVES FROM CONCEALED
C                                      POSITION
C SCENARIO 10: STATIONARY OBJECT ON ROADWAY
C SCENARIO 11: STATIONARY OBJECT ON ROADWAY: ONCOMING VEHICLE
C
C INITIALIZE AND PERFORM OUT-OF-THE-LOOP CALCULATIONS
C
        INDX1 = 1
        INDX2 = 1
        INDX3 = 1
        INDX4 = 1
        INDX5 = 1
        INDX6 = 1
        INDX7 = 1
        INDX8 = 1
        INDX9 = 1
        INDX10 = 1
        INDX11 = 1
        YOV = 0
        YLV = 0
        YNV = -LW
        PI = 4.0*ATAN(1.0)
        DEGRAD = PI/180.
        RADEG  = 1.0/DEGRAD
        COEFLV  = 10.0*PI*TRANS
        RADGS4 = 4.0*RADEG*RADEG
        M2DPI = -2.0/PI
        SUM = 0
        DO 5 IC = 1, NCAT
        SUM = SUM + PCAT(IC)
    5   PCATC(IC) = SUM
C
C SCENARIO:    1  2  3  4  5  6  7  8  9 10 11
```

FIGURE B-3. (continued)

```
      GO TO(10,20,10,10,20,50,50,50,60,60,60),MSCEN
C
C SCENARIOS 1, 3, AND 4  -  PROBABILITY OF LINE OF SIGHT, OBJECT AND
C                             BACKGROUND LUMINANCE
 10      PLOS = 1.0
C
C SCENARIOS 2 AND 5  -  PROBABILITY OF LINE OF SIGHT, OBJECT AND
C                          BACKGROUND LUMINANCE
 20      LO = TRANS*IO*PI/AMAX1(VO*HO,0.001)
         IF(MNITE .EQ. 1) GO TO 40
C
C          DAYTIME
           CBSUNB = AMAX1(COS(BSUNB*DEGRAD),0.0)
           LB = TRANS*RB*(ESKY + ESUN*CBSUNB)
           GO TO 45
C
C        NIGHTTIME
 40      LB = TRANS*IB*PI/AMAX1(VO*HO,0.001)
C
C        SAVE INITIAL XO
 45      XOI = XOV*CHDOV - YOV*SHDOV - X
         GO TO 80
C
C SCENARIOS 6, 7, AND 8  -  PROBABILITY OF DETECTING CHANGE IN
C                             HEADWAY, OBJECT AND BACKGROUND LUMINANCE
 50      PHO = 0.0
         IF(MNITE .EQ. 0) GO TO 70
C
C          NIGHTTIME
           LO = 0.0
           LB = 0.0
           GO TO 80
C
C j8*J]nnKbb9EkIOBABILITY OF LINE-OF-SIGHT, DETECTING
C                                CHANGE IN HEADWAY, DAYTIME OBJECT AND
C                                BACKGROUND LUMINANCE
 60      PLOS = 1.0
         PHO = 0.0
         IF(MNITE .EQ. 1) GO TO 80
C
C          DAYTIME
 70        CBSUNO = AMAX1(COS(BSUNO*DEGRAD),0.0)
           LO = TRANS*RO*(ESKY + ESUN*CBSUNO)
           CBSUNB = AMAX1(COS(BSUNB*DEGRAD),0.0)
           LB = TRANS*RB*(ESKY + ESUN*CBSUNB)
           IF(HOBJ .GE. HEYE) LB = TRANS*LSKY
C
C ALL SCENARIOS  -  ADAPTATION LUMINANCE, INITIALIZE VEILING LUMINANCE
C
 80      LA = TRANS*LSUR
         LV = 0.0
C
C
C **** IN-THE-LOOP CALCULATIONS ****
C
      DTCTF = 0
      TIMEP = TIME
      TAUF = 0.0
      TAUFP = 0.0
C
C DETERMINE FIXATION CATEGORY
```

FIGURE B-3. (continued)

```
C
   90 TI = RAND(1,0.0,1.0,0,0.0,0.0)
      DO 100 IC = 1,NCAT
         IF(TI .LE. PCATC(IC)) GO TO 110
  100 CONTINUE
C
C FIXATION CATEGORY IS A BLINK - UPDATE TIME, SCENARIO; CHECK FOR COLL.
C
      IC = NCAT + 1
      TAUB = RAND(4,TAUBM,TAUBS,0,0.0,0.0)
      TIME = TIME + TAUB
      X = X + UH*(TIME-TIMEP)
      CALL SCEN(1)
      CALL COLL(0)
      TIMEP = TIME
      TAUFP = TAUF
      IF(COLLF .EQ. 1) GO TO 335
      IF(MPRT .LT. 2) GO TO 90
      WRITE(9,1010) TIME
      GO TO 90
C
C FIXATION CATEGORY IS NOT A BLINK - COMPUTE FIXATION ANGLE AND DURATION
C
  110 THF  = RAND(3,THFM(IC),THFS(IC),0,0.0,0.0)
      PSF  = RAND(3,PSFM(IC),PSFS(IC),0,0.0,0.0)
      TAUF = RAND(4,TAUFM(IC),TAUFS(IC),0,0.0,0.0)
      TIME = TIME + 0.5*(TAUF+TAUFP)
      X = X + UH*(TIME-TIMEP)
      CALL SCEN(1)
      CALL COLL(0)
      TIMEP = TIME
      TAUFP = TAUF
      IF(COLLF .EQ. 1) GO TO 335
C
C OBJECT LOCATION
C
      XO = XOV*CHDOV - YOV*SHDOV - X
      YO = XOV*SHDOV + YOV*CHDOV - Y
      ZO = HOBJ - HEYE
      THO = ATAN2(ZO,XO)*RADEG
      PSO = ATAN2(YO,XO)*RADEG
      A1 = (THO - THF)*DEGRAD
      A2 = (PSO - PSF)*DEGRAD
      T1 = TAN(A1)
      T2 = TAN(A2)
      AO = ATAN(SQRT(T1*T1 + T2*T2))*RADEG
      IF(ABS(A1).GE.90.0 .OR. ABS(A2).GE.90.0) AO = 1.0E20
C
C FIXED GLARE SOURCE LOCATIONS
C
      IF(NGLARE .LE. 0) GO TO 130
        DO 120 I = 1,NGLARE
          A1 = (THG(I) - THF)*DEGRAD
          A2 = (PSG(I) - PSF)*DEGRAD
          T1 = TAN(A1)
          T2 = TAN(A2)
          AG(I) = AMAX1(ATAN(SQRT(T1*T1 + T2*T2))*RADEG,ALPHMN)
          IF(ABS(A1).GE.90.0 .OR. ABS(A2).GE.90.0) AG(I) = 1.0E20
  120   CONTINUE
C
```

FIGURE B-3. (continued)

```
C OBJECT SIZE
C
  130 T1 = 2.0*SQRT(XO*XO + YO*YO)
      AREAO = ATAN2(VO,T1)*ATAN2(HO,T1)*RADGS4
C
C IN-THE-LOOP LUMINANCE CALCULATIONS
C SCENARIO:  1    2    3    4    5    6    7    8    9   10   11
      GO TO(200,200,200,170,170,190,190,190,140,140,140),MSCEN
C
C SCENARIOS 9, 10, AND 11
C
  140    IF(MNITE .EQ. 0) GO TO 200
C
C           NIGHTTIME
            GVO = ATAN2(HOBJ-HLITE,XO)*RADEG
            ISVO = FLOOK1(GVO,YID,INDX1,FYD,NPTD)
            LO = TRANS*RO*(ISVO/AMAX1(XO*XO,0.001) + EO)
            IF(THO .GE. 0.0) GO TO 150
              XB = XO/(1.0 - HOBJ/HEYE)
              GVB = ATAN2(-HLITE,XB)*RADEG
              ISVB = FLOOK1(GVB,YID,INDX2,FYD,NPTD)
              LB = TRANS*RB*(ISVB/AMAX1(XB*XB,0.001) + EB)
              GO TO 160
  150       LB = TRANS*LSKY
  160       IF(MSCEN .EQ. 11) GO TO 170
              GO TO 200
C
C SCENARIOS 4 AND 5 (AND 11)
C
C        ONCOMING VEHICLE LOCATION
  170    IF(MNITE .EQ. 0) GO TO 200
C
C           NIGHTTIME
            XN = XNV - X
            YN = YNV - Y
            ZN = HLITE - HEYE
            THN = ATAN2(ZN,XN)*RADEG
            PSN = ATAN2(YN,XN)*RADEG
            A1 = (THN - THF)*DEGRAD
            A2 = (PSN - PSF)*DEGRAD
            T1 = TAN(A1)
            T2 = TAN(A2)
            AN = AMAX1(ATAN(SQRT(T1*T1 + T2*T2))*RADEG,ALPHMN)
            IF(ABS(A1).GE.90.0 .OR. ABS(A2).GE.90.0) AN = 1.0E20
            IF(XN .LE. 0.0) GO TO 200
              DN = SQRT(XN*XN + YN*YN)
              INV = FLOOK2(PSN,-THN,XIE,INDX3,YIE,INDX4,FXYE,NPTXE,NPTYE,
     1              20)
              LVI = INV/(DN*DN*AN*AN)
              GO TO 210
C
C SCENARIOS 6, 7, AND 8
C
  190    IF(MNITE .EQ. 1) GO TO 240
C
C UPDATE VEILING LUMINANCE
C ALL SCENARIOS EXCEPT 6, 7, 8 (NIGHT)
C
  200    LVI = 0.0
  210    IF(NGLARE .LE. 0) GO TO 230
           DO 220 I = 1,NGLARE
```

FIGURE B-3. (continued)

```
         LVI = LVI + EG(I)/(AG(I)*AG(I))
  220      CONTINUE
  230    LVI = COEFLV*LVI
         IF(LV .EQ. 0.0) LV = LVI
         T1 = KV1
         T2 = LV - LVI
         IF(T2 .GE. 0.0) T1 = KV2
         LV = LVI + T2*EXP(-T1*TAUF)
C
C ALL SCENARIOS  -  APPARENT CONTRAST
C
  240    LAPLV = LA + LV
         CAPPO = ABS(LO - LB)/AMAX1(LAPLV,0.001)
C
C ALL SCENARIOS  -  FOVEAL AND PERIPHERAL THRESHOLD CONTRAST
C
         ALAPLV = ALOG10(LAPLV)
         AAREAO = ALOG10(AREAO)
         CFOVO = FLOOK2(AAREAO,ALAPLV,XIF,INDX5,YIF,INDX6,FXYF,
     1              NPTXF,NPTYF,IO)
         CPERO = FLOOK2(AAREAO,AO,XIG,INDX8,YIG,INDX9,FXYG,
     1              NPTXG,NPTYG,IO)
C
C ALL SCENARIOS  -  THRESHOLD AND RELATIVE CONTRAST
C
         CTHO = 10.0**(CFOVO+CPERO)
         CRELO = CAPPO/AMAX1(CTHO,0.001)
C
C LEAD VEHICLE CALCULATIONS AND EVENT DETECTION PARAMETERS
C SCENARIO:  1   2   3   4   5   6   7   8   9  10  11
      GO TO(260,250,260,260,250,270,270,270,280,280,280),MSCEN
C
C SCENARIOS 2 AND 5
C
C        LEAD VEHICLE LOCATION
  250    XL = XLV - X
         YL = YLV - Y
         ZL = HOBJ - HEYE
         THL = ATAN2(ZL,XL)*RADEG
         PSL = ATAN2(YL,XL)*RADEG
         A1 = (THL - THF)*DEGRAD
         A2 = (PSL - PSF)*DEGRAD
         T1 = TAN(A1)
         T2 = TAN(A2)
         AL= ATAN(SQRT(T1*T1 + T2*T2))*RADEG
         IF(ABS(A1).GE.90.0 .OR. ABS(A2).GE.90.0) AL = 1.0E20
C
C        LEAD VEHICLE SIZE
         T1= 2.0*SQRT(XL*XL +YL*YL)
         AREAL = ATAN2(VO,T1)*ATAN2(HO,T1)*RADGS4
C
C        LEAD VEHICLE FOVEAL AND PERIPHERAL THRESHOLD CONTRAST
         AAREAL = ALOG10(AREAL)
         CFOVL = FLOOK2(AAREAL,ALAPLV,XIF,INDX7,YIF,INDX6,FXYF,
     1              NPTXF,NPTYF,IO)
         CPERL = FLOOK2(AAREAL,AL,XIG,INDX10,YIG,INDX11,FXYG,
     1              NPTXG,NPTYG,IO)
C
C        LEAD VEHICLE THRESHOLD, APPARENT, AND RELATIVE CONTRAST
```

FIGURE B-3. (continued)

```
      CTHL = 10.0**(CFOVL+CPERL)
      CAPPL = KL*CAPPO
      CRELL = CAPPL/AMAX1(CTHL,0.001)
C
C SCENARIOS 1, 3, AND 4  -  PROBABILITY OF DETECTING CHANGE IN HEADWAY
C
  260 PHO = 0.0
      IF(((XOI-XO) .GT. HRTH*XOI) .AND. (AO .LE. HPER)) PHO = 1.0
      GO TO 280
C
C SCENARIOS 6, 7, AND 8  -  PROBABILITY OF LINE-OF-SIGHT TO LEAD VEHICLE
C
  270 I = (PSO + 90.0)/5.0 + 1
      IF(I .LT. 1) I = 1
      IF(I .GT. 36) I = 36
      PLOS = PMERG(I)
C
C DETECTION PROBABILITY DUE TO OBJECT BACKGROUND CONTRAST
C
  280 T1 = (CRELO - 1.0)/SIGC
      T2 = 0.5
      IF(CRELO .LT. 2.0) T2 = 0.5*SQRT(1.0 - EXP(M2DPI*T1*T1))
      PCO = 0.5 + SIGN(T2,T1)
      IF(AO .GE. 90.0) PCO = 0.0
C
C DETECTION PROBABILITY
C SCENARIO:  1   2   3   4   5   6   7   8   9  10  11
      GO TO(310,300,310,310,300,320,320,320,310,310,310),MSCEN
C
C SCENARIOS 2 AND 5
C
C     LEAD VEHICLE DETECTION PROBABILITY DUE TO BACKGROUND CONTRAST
  300 T1 = (CRELL - 1.0)/SIGC
      T2 = 0.5
      IF(CRELL .LT. 2.0) T2 = 0.5*SQRT(1.0 - EXP(M2DPI*T1*T1))
      PCL = 0.5 + SIGN(T2,T1)
      IF(AL .GE. 90.0) PCL = 0.0
C
C     OBJECT DETECTION PROBABILITY
      PDO = PCO + PHO - PCO*PHO
      PDL = PLITE*PCL
      PD = PDO + PDL - PDO*PDL
      GO TO 330
C
C SCENARIOS 1, 3, 4, 9, 10, AND 11  -  OBJECT DETECTION PROBABILITY
C
  310 PD = PCO + PHO - PCO*PHO
      GO TO 330
C
C SCENARIOS 6, 7, AND 8  -  OBJECT DETECTION PROBABILITY
C
  320 PD = PLOS*PCO
C
C DETERMINE IF OBJECT DETECTION OCCURS
C
  330 T1 = RAND(1,0.0,1.0,0,0.0,0.0)
      IF(T1 .LE. PD) GO TO 340
C
C OBJECT DETECTION DID NOT OCCUR
C
  335 IF(MPRT .LT. 2) GO TO 337
```

FIGURE B-3. (continued)

```
      WRITE(9,1000) TIME,
     1      IC,DTCTF,X,THF,PSF,TAUF,PLOS,    LA,
     2      XO,YO,ZO,THO,PSO,AO,GVO,ISVO,LO,
     3      XL,YL,ZL,THL,PSL,AL,GVB,ISVB,LB,
     4      XN,YN,ZN,THN,PSN,AN,      INV  ,LV,
     5      AREAO,CAPPO,CFOVO,CPERO,CTHO,CRELO,PDO,PCO,PHO,
     6      AREAL,CAPPL,CFLVL,CPERL,CTHL,CRELL,PDL,PCL,PD
C
C RETURN IF COLLISION HAS OCCURED
C
  337 IF(COLLF .EQ. 1) RETURN
      GO TO 90
C
C OBJECT DETECTION DID OCCUR
C
  340 TIME = TIME + RAND(4,TAURDM,TAURDS,0,0.0,0.0)
      X = X + UH*(TIME-TIMEP)
      CALL SCEN(1)
      DTCTF = 1
      IF(MPRT .LT. 2) RETURN
      WRITE(9,1000) TIME,
     1      IC,DTCTF,X,THF,PSF,TAUF,PLOS,    LA,
     2      XO,YO,ZO,THO,PSO,AO,GVO,ISVO,LO,
     3      XL,YL,ZL,THL,PSL,AL,GVB,ISVB,LB,
     4      XN,YN,ZN,THN,PSN,AN,      INV  ,LV,
     5      AREAO,CAPPO,CFOVO,CPERO,CTHO,CRELO,PDO,PCO,PHO,
     6      AREAL,CAPPL,CFLVL,CPERL,CTHL,CRELL,PDL,PCL,PD
      RETURN
      END
```

FIGURE B-3. (concluded)

```
      SUBROUTINE DECISN(MODE)
C
C     DRIVER MANEUVER DECISION MODEL FOR 11 SCENARIOS
C
      REAL IXX,IYY,IZZ,KF,KR,MUXF,MUXR,MUYF,MUYR,KSW,KBF,KBR,KSC
      REAL LW
      REAL LSVF,LSVR,LOV
      REAL IO,IB,LSKY,LSUR,KL,KV1,KV2
      REAL MPHFPS,MANDEC,LAV,LF,LR
      INTEGER COLLF,DTCTF
C
      COMMON /STATES/
     1     UH,VH,WH,X,Y,Z,
     2     WX,WY,WZ,PHI,THE,PSI,
     3     UOV,XOV,ULV,XLV,UNV,XNV
C
      COMMON /DERIVS/
     1     UHD,VHD,WHD,XD,YD,ZD,
     2     WXD,WYD,WZD,PHID,THED,PSID,
     3     UOVD,XOVD,ULVD,XLVD,UNVD,XNVD
C
      COMMON /CONT/ DELSW,DELB
C
      COMMON /PARAM/
     1     UHO,VHO,WHO,XO,YO,ZO,
     2     WXO,WYO,WZO,PHIO,THEO,PSIO,
     3     WEIGHT,IXX,IYY,IZZ,
     4     DF,DR,TF,TR,ZF,ZR,HF,HR,
     5     KF,KR,CF,CR,
     6     MUXF,MUXR,MUYF,MUYR,BETASF,BETASR,SNR,
     7     KSW,KBF,KBR,
     8     KSC,UCMD,TDMAX,
     9     MANDEC,TAUR,TAUP,WC,VETH,YETH,
     A     ABR,ABSTB,ABSTC,ASWS,ASWC,TSW,SWMAX,SWRMAX,
     B     HOV,UOVO,DOVG,HLV,ULVO,DLVG,HNVMIN,HNVAVE,UNVO,DISTSO,DISTNS,
     C     PSIB,LW,TAUD,TAUOVD,
     D     LAV,HAVMIN,HAVAVE,LF,LR,PBO,PSO,PA,TTHRSH,DTHRSH,TLOOK,
     E     ESKY,ESUN,RO,EO,IO,BSUNO,RB,EB,IB,BSUNB,LSKY,LSUR,
     F     TRANS,KL,VO,HO,PLITE,HRTH,HPER,SIGC,KV1,KV2,ALPHMN,
     G     HEYE,HLITE,HOBJ,TAUBM,TAUBS,TAURDM,TAURDS,
     H     LSVF,LSVR,WSV,LOV,WOV,UHTH,VHTH
C
      COMMON
     *     MSCEN,MNITE,MDET,MADJ,MVEH,MSTOR,MPRT,
     *     NU,NX,NVAR,NTRIAL,ISEED,DT,DTPRT,DTSTOR,TMAX,
     *     DEGRAD,MPHFPS,G,TIME,MDEC,COLLF,DTCTF,CHDOV,SHDOV,CPSI,SPSI,
     *     FHX,FHY,FHZ,THX,THY,THZ,BETA,HEAD,VTOT,VX,VY,ATOT,AX,AY,
     1     UH1,VH1,WH1,Z1,FX1,FY1,FN1,BET1,FC1,FS1,
     2     UH2,VH2,WH2,Z2,FX2,FY2,FN2,BET2,FC2,FS2,
     3     UH3,VH3,WH3,Z3,FX3,FY3,FN3,BET3,FC3,FS3,
     4     UH4,VH4,WH4,Z4,FX4,FY4,FN4,BET4,FC4,FS4
C
C SCENARIO  1: FOLLOWING; FREEWAY
C SCENARIO  2: FOLLOWING: FREEWAY: INTERVENING VEHICLE
C SCENARIO  3: FOLLOWING; FREEWAY ENTRANCE RAMP
C SCENARIO  4: FOLLOWING: URBAN STREET
C SCENARIO  5: FOLLOWING; URBAN STREET: INTERVENING VEHICLE
C SCENARIO  6: LATERALLY MOVING VEHICLE; FREEWAY ENTRANCE RAMP
C SCENARIO  7: LATERALLY MOVING VEHICLE: INTERSECTION: VEHICLE APPROACH
C                                                          FROM RIGHT
C
```

FIGURE B-4. <u>SUBROUTINE DECISN</u> PROGRAM LISTING

```
C SCENARIO  8: LATERALLY MOVING VEHICLE; INTERSECTION; VEHICLE APPROACH
C                                                        FROM LEFT
C SCENARIO  9: OBJECT ON ROADWAY; PEDESTRIAN MOVES FROM CONCEALED
C                                  POSITION
C SCENARIO 10: STATIONARY OBJECT ON ROADWAY
C SCENARIO 11: STATIONARY OBJECT ON ROADWAY: ONCOMING VEHICLE
C
C DETERMINE IF MODE IS INITIALIZATION (<=0) OR EVALUATION (> 0)
C
      IF(MODE .GT. 0) GO TO 2000
C
C*****INITIALIZATION****
C
C COMPUTE ADJACENT VEHICLE PROBABILITIES FOR SAFE-MANEUVERING REGIONS
C
      HDIFF = HAVAVE - HAVMIN
      HAVAVE = AMAX1(HAVAVE,0.001)
      HRATIO = HDIFF/HAVAVE
      HDIFF = AMAX1(HDIFF,0.001)
C
C     FRONT
      TMP  = LAV + LF
      PF   = TMP/HAVAVE
      IF(TMP .GT. HAVMIN) PF   = 1.0 - HRATIO*EXP((HAVMIN-TMP)/HDIFF)
C
C     REAR
      TMP = LAV + LR
      PR  = TMP/HAVAVE
      IF(TMP .GT. HAVMIN) PR   = 1.0 - HRATIO*EXP((HAVMIN-TMP)/HDIFF)
C
C     FRONT OR REAR
      TMP  = LAV + LF + LR
      PFOR = TMP/HAVAVE
      IF(TMP .GT. HAVMIN) PFOR = 1.0 - HRATIO*EXP((HAVMIN-TMP)/HDIFF)
C
      PNFR = PFOR - PF
      PCO  = 1.0 - PSO - PBO
      PSCO = PSO + PCO
      PNA  = 1.0 - PA
C
C INITIALIZE FOR APPROPRIATE SCENARIO
C SCENARIO:    1   2   3   4   5   6   7   8   9   10  11
      GO TO (100,100,300,300,300,600,300,300,600,300,300),MSCEN
C
C COMPUTE CONDITIONAL PROBABILITIES FOR MANEUVER CHANGE: COLLISION: LOOK
C
C     SCENARIOS 1, 2
  100 PXGV    = PFOR*PFOR
      PXGNV   = PA*PXGV + PNA*PF*PF
      PNXGV   = 1.0 - PXGV
      PNXGNV  = 1.0 - PXGNV
C
      PSGV = PSO*PNXGV
      PCGV = PCO*PNXGV
      PBGV = 1.0 - PSGV - PCGV
      PNCGV = 1.0 - PCGV
C
      PSGNV  = PSO*PNXGNV
      PCGNV  = PCO*PNXGNV
      PNCGNV = 1.0 - PCGNV
```

FIGURE B-4. (continued)

```
C
      PCLGS = PNA*(1.0 + PF)*PNFR/AMAX1(PNXGNV,0.001)
      PCLGC = PCLGS
C
      PLKGS = PNA
      PLKGC = PNA
      PLKGB = PSCO*PNA*PNFR*(PFOR + PF)/AMAX1(PBGV,0.001)
C
      TSMIN = 0
      RETURN
C
C     SCENARIOS 3, 4, 5, 7, 8, 10, 11
  300 PS = PSO
      PC = PCO
      PNC = 1.0 - PC
      RETURN
C
C     SCENARIOS 6, 9
  600 PXGV   = PFOR
      PXGNV  = PA*PFOR + PNA*PF
      PNXGV  = 1.0 - PXGV
      PNXGNV = 1.0 - PXGNV
C
      PSGV = PSO*PNXGV
      PCGV = PCO*PNXGV
      PBGV = 1.0 - PSGV - PCGV
      PNCGV = 1.0 - PCGV
C
      PSGNV = PSO*PNXGNV
      PCGNV = PCO*PNXGNV
      PNCGNV = 1.0 - PCGNV
C
      PCLGS = PNA*PNFR/AMAX1(PNXGNV,0.001)
      PCLGC = PCLGS
C
      PLKGS = PNA
      PLKGC = PNA
      PLKGB = PSCO*PNA*PNFR/AMAX1(PBGV,0.001)
C
      TSMIN = 2.0*UH/G
      RETURN
C
C
C*****IN THE LOOP (EVALUATION)*****
C
C DETERMINE MANEUVER DECISION: COLLISION WITH ADJACENT VEHICLES:
C AND LOOK FOR ADJACENT VEHICLES
C
 2000 RN1 = RAND(1,0.0,1.0,0,0.0,0.0)
      RN2 = RAND(1,0.0,1.0,0,0.0,0.0)
C
C SCENARIO:   1    2    3    4    5    6    7    8    9    10   11
      GO TO (2100,2100,3050,2400,2400,2100,3050,3050,2100,3050,2400),
     1                                                           MSCEN
C
C     SCENARIOS: 1, 2, 6, 9
 2100 IF(MADJ .EQ. 0) GO TO 3000
        TREACT = (XOV - X)/AMAX1(UH,0.001) - TSMIN
        IF((TREACT-TTHRSH) .LT. 0.0) GO TO 2160
C
```

FIGURE B-4. (continued)

```
C DETERMINE MANEUVER DECISION GIVEN TIME TO REACT AND
C UPDATE TIME TO ACCOUNT FOR DRIVER CHECKING FOR ADJACENT TRAFFIC
C
          IF(RN1 .LE. PSGV) GO TO 2120
          IF(RN1 .GT. PNCGV) GO TO 2130
          MDEC = 1
            IF(RN2 .LE. PLKGB) TIME = TIME + TLOOK
              RETURN
 2120     MDEC = 2
            IF(RN2 .LE. PLKGS) TIME = TIME + TLOOK
              RETURN
 2130     MDEC = 3
            IF(RN2 .LE. PLKGC) TIME = TIME + TLOOK
              RETURN
C
C COMPUTE MANEUVER DECISION GIVEN NO TIME TO REACT AND
C DETERMINE COLLISIONS WITH ADJACENT VEHICLES
C
 2160 IF(RN1 .LE. PSGNV) GO TO 2170
      IF(RN1 .GT. PNCGNV) GO TO 2180
      MDEC = 1
        RETURN
 2170 MDEC = 2
        IF(RN2 .LE. PCLGS) COLLF = 2
          RETURN
 2180 MDEC = 3
        IF(RN2 .LE. PCLGC) COLLF = 2
          RETURN
C
C COMPUTE MANEUVER DECISION CONDITIONED ON GAP SIZE IN ONCOMING TRAFFIC
C
C     SCENARIOS: 4, 5, 11
 2400 IF(MADJ .EQ. 0) GO TO 3050
      GAP = XNV - X - TMP
      MDEC = 1
      IF(GAP .LT. DTHRSH) RETURN
      GO TO 3050
C
 3000   PS = PS0
        PC = PC0
        PNC = 1.0 - PC
 3050 MDEC = 1
      IF(RN1 .LE. PS) MDEC = 2
      IF(RN1 .GT. PNC) MDEC = 3
      RETURN
      END
```

FIGURE B-4. (concluded)

```
      SUBROUTINE VEH6(MODE)
C
C 6 DOF VEHICLE MODEL
C
      REAL IXX,IYY,IZZ,KF,KR,MUXF,MUXR,MUYF,MUYR,KSW,KBF,KBR,KSC
      REAL LW
      REAL LSVF,LSVR,LOV
      REAL IO,IB,LSKY,LSUR,KL,KV1,KV2
      REAL MPHFPS,MANDEC,LAV,LF,LR
      INTEGER COLLF,DTCTF
      REAL KSTAB
      REAL MASS,KBHF,KBHR,KBHCF,KBHCR,KBHCG,MUXHCF,MUXHCR
C
      COMMON /STATES/
     1     UH,VH,WH,X,Y,Z,
     2     WX,WY,WZ,PHI,THE,PSI,
     3     UOV,XOV,ULV,XLV,UNV,XNV
C
      COMMON /DERIVS/
     1     UHD,VHD,WHD,XD,YD,ZD,
     2     WXD,WYD,WZD,PHID,THED,PSID,
     3     UOVD,XOVD,ULVD,XLVD,UNVD,XNVD
C
      COMMON /CONT/ DELSW,DELB
C
      COMMON /PARAM/
     1     UHO,VHO,WHO,XO,YO,ZO,
     2     WXO,WYO,WZO,PHIO,THEO,PSIO,
     3     WEIGHT,IXX,IYY,IZZ,
     4     DF,DR,TF,TR,ZF,ZR,HF,HR,
     5     KF,KR,CF,CR,
     6     MUXF,MUXR,MUYF,MUYR,BETASF,BETASR,SNR,
     7     KSW,KBF,KBR,
     8     KSC,UCMD,TDMAX,
     9     MANDEC,TAUR,TAUP,WC,VETH,YETH,
     A     ABR,ABSTB,ABSTC,ASWS,ASWC,TSW,SWMAX,SWRMAX,
     B     HOV,UOVO,DOVG,HLV,ULVO,DLVG,HNVMIN,HNVAVE,UNVO,DISTSO,DISTNS,
     C     PSIB,LW,TAUD,TAUOVD,
     D     LAV,HAVMIN,HAVAVE,LF,LR,PBO,PSO,PA,TTHRSH,DTHRSH,TLOOK,
     E     ESKY,ESUN,RO,EO,IO,BSUNO,RB,EB,IB,BSUNB,LSKY,LSUR,
     F     TRANS,KL,VO,HO,PLITE,HRTH,HPER,SIGC,KV1,KV2,ALPHMN,
     G     HEYE,HLITE,HOBJ,TAUBM,TAUBS,TAURDM,TAURDS,
     H     LSVF,LSVR,WSV,LOV,WOV,UHTH,VHTH
C
      COMMON
     *     MSCEN,MNITE,MDET,MADJ,MVEH,MSTOR,MPRT,
     *     NU,NX,NVAR,NTRIAL,ISEED,DT,DTPRT,DTSTOR,TMAX,
     *     DEGRAD,MPHFPS,G,TIME,MDEC,COLLF,DTCTF,CHDOV,SHDOV,CPSI,SPSI,
     *     FHX,FHY,FHZ,THX,THY,THZ,BETA,HEAD,VTOT,VX,VY,ATOT,AX,AY,
     1     UH1,VH1,WH1,Z1,FX1,FY1,FN1,BET1,FC1,FS1,
     2     UH2,VH2,WH2,Z2,FX2,FY2,FN2,BET2,FC2,FS2,
     3     UH3,VH3,WH3,Z3,FX3,FY3,FN3,BET3,FC3,FS3,
     4     UH4,VH4,WH4,Z4,FX4,FY4,FN4,BET4,FC4,FS4
C
      TAN(X) = SIN(X)/COS(X)
C
      IF(MODE .NE. 0) GO TO 100
C
C*****INITIALIZATION*****
C
```

FIGURE B-5. SUBROUTINE VEH6 PROGRAM LISTING

```
      MASS = WEIGHT/G
      WB = DF + DR
      TI = 0.5*WEIGHT/WB
      WF = TI*DR
      WR = TI*DF
      ZHF = ZF + HF
      ZHR = ZR + HR
      HCG = (ZHF*DF + ZHR*DR)/WB
C
      BETSF = BETASF*DEGRAD
      BETSR = BETASR*DEGRAD
      SMUXF = SNR*MUXF
      SMUXR = SNR*MUXR
      SMUYF = SNR*MUYF
      SMUYR = SNR*MUYR
      ROFSQ = (SMUYF/SMUXF)**2
      RORSQ = (SMUYR/SMUXR)**2
      CSF = 1.5*SMUYF/BETSF
      CSR = 1.5*SMUYR/BETSR
      KSTAB = (1.0/CSF - 1.0/CSR)/(G*WB)
      GCSR = G*CSR
      UTH = 2.0*GCSR*DT
      VTH = 2.0*G*DT*(SMUYF*DR + SMUYR*DF)/WB
      HR2 = 2.0*HR
C
      WDF = 0.5*WEIGHT*DF
      WDR = 0.5*WEIGHT*DR
      KBHF = KBF/HF
      KBHR = KBR/HR
      KBHCF = KBHF*HCG
      KBHCR = KBHR*HCG
      KBHCG = KBHCF + KBHCR
C
      MUXHCF = SMUXF*HCG
      MUXHCR = SMUXR*HCG
      DENOM = WB - MUXHCF + MUXHCR
      TEMP = 0.5*WEIGHT/DENOM
      FBFMX = SMUXF*TEMP*(DR + MUXHCR)
      FBRMX = SMUXR*TEMP*(DF - MUXHCF)
      FBMAX = 2.0*(FBFMX + FBRMX)
      DBPMAX = AMAX1(FBFMX/KBHF,FBRMX/KBHR)
C
      RETURN
C
C*****IN THE LOOP*****
C
C COMPUTE STEERING, BRAKING, AND DRIVE FORCES
C
  100 DELW = KSW*DEGRAD*DELSW
      DELBP = DELB*DBPMAX
      FT = 0
      IF(DELB .EQ. 0.0) FT = AMIN1(-KSC*(UH-UCMD),TDMAX)/HR2
      FBF = KBHF*DELBP
      FBR = KBHR*DELBP
      CDELW = COS(DELW)
      SDELW = SIN(DELW)
C
C COMPUTE DISPLACEMENTS, VELOCITIES, AND FORCES AT EACH WHEEL
C
C     VERTICAL DISPLACEMENTS
```

FIGURE B-5. (continued)

```
      T1 = TF*PHI
      T2 = DF*THE
      T3 = TR*PHI
      T4 = DR*THE
      Z1 = Z + T1 - T2
      Z2 = Z - T1 - T2
      Z3 = Z + T3 + T4
      Z4 = Z - T3 + T4
C
C     WHEEL VELOCITIES IN BODY FRAME
      T1 = WZ*TF
      T2 = WY*ZF
      T3 = WZ*TR
      T4 = WY*ZR
      U1 = - T1 + T2
      U2 = + T1 + T2
      U3 = - T3 + T4
      U4 = + T3 + T4
C
      V1 = WZ*DF - WX*HCG
      V2 = V1
      V3 =-WZ*DR - WX*HCG
      V4 = V3
C
      T1 = WX*TF
      T2 = WY*DF
      T3 = WX*TR
      T4 = WY*DR
      W1 = + T1 - T2
      W2 = - T1 - T2
      W3 = + T3 + T4
      W4 = - T3 + T4
C
C     WHEEL VELOCITIES IN HORIZONTAL BODY FRAME
      UH1 = UH + U1 + THE*W1
      UH2 = UH + U2 + THE*W2
      UH3 = UH + U3 + THE*W3
      UH4 = UH + U4 + THE*W4
C
      VH1 = VH + V1 - PHI*W1
      VH2 = VH + V2 - PHI*W2
      VH3 = VH + V3 - PHI*W3
      VH4 = VH + V4 - PHI*W4
C
      WH1 = WH + W1 - THE*U1 + PHI*V1
      WH2 = WH + W2 - THE*U2 + PHI*V2
      WH3 = WH + W3 - THE*U3 + PHI*V3
      WH4 = WH + W4 - THE*U4 + PHI*V4
C
C     TIRE SIDESLIP
      BET1 = ATAN(VH1/AMAX1(ABS(UH1),0.001)) - DELW*SIGN(1.0,UH1)
      BET2 = ATAN(VH2/AMAX1(ABS(UH2),0.001)) - DELW*SIGN(1.0,UH2)
      BET3 = ATAN(VH3/AMAX1(ABS(UH3),0.001))
      BET4 = ATAN(VH4/AMAX1(ABS(UH4),0.001))
C
      BETN1 = SIGN(AMIN1(ABS(BET1/BETSF),1.0),BET1)
      BETN2 = SIGN(AMIN1(ABS(BET2/BETSF),1.0),BET2)
      BETN3 = SIGN(AMIN1(ABS(BET3/BETSR),1.0),BET3)
      BETN4 = SIGN(AMIN1(ABS(BET4/BETSR),1.0),BET4)
C
      TBET1 = TAN(BET1)
```

FIGURE B-5. (continued)

```
      TBET2 = TAN(BET2)
      TBET3 = TAN(BET3)
      TBET4 = TAN(BET4)
C
C     NORMAL TIRE FORCES
      FN1 = WF + KF*Z1 + CF*WH1
      FN2 = WF + KF*Z2 + CF*WH2
      FN3 = WR + KR*Z3 + CR*WH3
      FN4 = WR + KR*Z4 + CR*WH4
C
      FMY1 = SMUYF*FN1
      FMY2 = SMUYF*FN2
      FMY3 = SMUYR*FN3
      FMY4 = SMUYR*FN4
C
      FCM1 = FMY1/SQRT(ROFSQ + TBET1**2)
      FCM2 = FMY2/SQRT(ROFSQ + TBET2**2)
      FCM3 = FMY3/SQRT(RORSQ + TBET3**2)
      FCM4 = FMY4/SQRT(RORSQ + TBET4**2)
C
C     CIRCUMFERENTIAL TIRE FORCES
      FC1 = -SIGN(AMIN1(FBF,FCM1),UH1)
      FC2 = -SIGN(AMIN1(FBF,FCM2),UH2)
      FC3 = -SIGN(AMIN1(FBR,FCM3),UH3) + AMIN1(FT,SMUXR*FN3)
      FC4 = -SIGN(AMIN1(FBR,FCM4),UH4) + AMIN1(FT,SMUXR*FN4)
C
      FSM1 = SQRT(ABS(FMY1**2 - ROFSQ*FC1**2))
      FSM2 = SQRT(ABS(FMY2**2 - ROFSQ*FC2**2))
      FSM3 = SQRT(ABS(FMY3**2 - RORSQ*FC3**2))
      FSM4 = SQRT(ABS(FMY4**2 - RORSQ*FC4**2))
C
C     SIDE TIRE FORCES
      FS1 = 0.5*BETN1*(3.0 - BETN1**2)*FMY1 + FBF*TBET1
      FS2 = 0.5*BETN2*(3.0 - BETN2**2)*FMY2 + FBF*TBET2
      FS3 = 0.5*BETN3*(3.0 - BETN3**2)*FMY3 + FBR*TBET3
      FS4 = 0.5*BETN4*(3.0 - BETN4**2)*FMY4 + FBR*TBET4
C
      FS1 =-SIGN(AMIN1(ABS(FS1),FSM1),BET1)
      FS2 = -SIGN(AMIN1(ABS(FS2),FSM2),BET2)
      FS3 = -SIGN(AMIN1(ABS(FS3),FSM3),BET3)
      FS4 = -SIGN(AMIN1(ABS(FS4),FSM4),BET4)
C
C     LONGITUDINAL TIRE FORCES
      FX1 = FC1*CDELW- FS1*SDELW
      FX2 = FC2*CDELW - FS2*SDELW
      FX3 = FC3
      FX4 = FC4
C
C     LATERAL TIRE FORCES
      FY1 = FC1*SDELW + FS1*CDELW
      FY2 = FC2*SDELW + FS2*CDELW
      FY3 =             FS3
      FY4 =             FS4
C
C COMPUTE TOTAL FORCES AND MOMENTS IN HORIZONTAL BODY FRAME
C
      FHX = FX1 + FX2 + FX3 + FX4
      FHY = FY1 + FY2 + FY3 + FY4
      FHZ =-FN1 - FN2 - FN3 - FN4 + WEIGHT
C
```

FIGURE B-5. (continued)

```
      THX = TF*(FN2-FN1) + TR*(FN4-FN3) - HCG*FHY
      THY = DF*(FN1+FN2) - DR*(FN3+FN4) + HCG*FHX
      THZ = TF*(FX2-FX1) + TR*(FX4-FX3) + DF*(FY1+FY2) - DR*(FY3+FY4)
C
      IF(ABS(UH) .GT. UTH .OR. ABS(VH) .GT. VTH) GO TO 150
C
C UPDATE STATE DERIVATIVES FOR VELOCITIES BELOW THRESHOLD
C
      WZ = UH*DELW/(WB*(1.0 + KSTAB*UH**2))
      WX = -WZ*THE
      WXD = 0
      WYD = ((IZZ-IXX)*WZ*WX + THY)/IYY
      WZD = 0
C
      PHI = 0
      PHID = 0
      THED = WY
      PSID = WZ
C
      VH = (1.0 - UH/GCSR)*DR*WZ
      UHD = PSID*VH + FHX/MASS
      VHD = 0
      WHD = FHZ/MASS
      GO TO 200
C
C UPDATE ANGULAR RATE AND ATTITUDE DERIVATIVES IN BODY FRAME
C
  150 WXD = ((IYY-IZZ)*WY*WZ + THX - THE*THZ)/IXX
      WYD = ((IZZ-IXX)*WZ*WX + THY + PHI*THZ)/IYY
      WZD = ((IXX-IYY)*WX*WY + THZ + THE*THX - PHI*THY)/IZZ
C
      PHID = WX + WZ*THE
      THED = WY - WZ*PHI
      PSID = WZ + WY*PHI
C
C UPDATE VELOCITY DERIVATIVES IN HORIZONTAL BODY FRAME
C
      UHD = PSID*VH + FHX/MASS
      VHD =-PSID*UH + FHY/MASS
      WHD =           FHZ/MASS
C
C UPDATE POSITION DERIVATIVES IN INERTIAL FRAME
C
  200 XD = CPSI*UH - SPSI*VH
      YD = SPSI*UH + CPSI*VH
      ZD = WH
      RETURN
      END
```

FIGURE B-5. (concluded)

```
      SUBROUTINE VEH3(MODE)
C
C 3 DOF VEHICLE MODEL
C
      REAL IXX,IYY,IZZ,KF,KR,MUXF,MUXR,MUYF,MUYR,KSW,KBF,KBR,KSC
      REAL LW
      REAL LSVF,LSVR,LOV
      REAL IO,IB,LSKY,LSUR,KL,KV1,KV2
      REAL MPHFPS,MANDEC,LAV,LF,LR
      INTEGER COLLF,DTCTF
      REAL KSTAB
      REAL MASS,KBHF,KBHR,KBHCF,KBHCR,KBHCG,MUXHCF,MUXHCR
C
      COMMON /STATES/
     1     UH,VH,WH,X,Y,Z,
     2     WX,WY,WZ,PHI,THE,PSI,
     3     UOV,XOV,ULV,XLV,UNV,XNV
C
      COMMON /DERIVS/
     1     UHD,VHD,WHD,XD,YD,ZD,
     2     WXD,WYD,WZD,PHID,THED,PSID,
     3     UOVD,XOVD,ULVD,XLVD,UNVD,XNVD
C
      COMMON /CONT/ DELSW,DELB
C
      COMMON /PARAM/
     1     UHO,VHO,WHO,XO,YO,ZO,
     2     WXO,WYO,WZO,PHIO,THEO,PSIO,
     3     WEIGHT,IXX,IYY,IZZ,
     4     DF,DR,TF,TR,ZF,ZR,HF,HR,
     5     KF,KR,CF,CR,
     6     MUXF,MUXR,MUYF,MUYR,BETASF,BETASR,SNR.
     7     KSW,KBF,KBR,
     8     KSC,UCMD,TDMAX,
     9     MANDEC,TAUR,TAUP,WC,VETH,YETH,
     A     ABR,ABSTB,ABSTC,ASWS,ASWC,TSW,SWMAX,SWRMAX,
     B     HOV,UOVO,DOVG,HLV,ULVO,DLVG,HNVMIN,HNVAVE,UNVO,DISTSO,DISTNS,
     C     PSIB,LW,TAUD,TAUOVD,
     D     LAV,HAVMIN,HAVAVE,LF,LR,PBO,PSO,PA,TTHRSH,DTHRSH,TLOOK,
     E     ESKY,ESUN,RO,EO,IO,BSUNO,RB,EB,IB,BSUNB,LSKY,LSUR,
     F     TRANS,KL,VO,HO,PLITE,HRTH,HPER,SIGC,KV1,KV2,ALPHMN,
     G     HEYE,HLITE,HOBJ,TAUBM,TAUBS,TAURDM,TAURDS,
     H     LSVF,LSVR,WSV,LOV,WOV,UHTH,VHTH
C
      COMMON
     *     MSCEN,MNITE,MDET,MADJ,MVEH,MSTOR,MPRT,
     *     NU,NX,NVAR,NTRIAL,ISEED,DT,DTPRT,DTSTOR,TMAX,
     *     DEGRAD,MPHFPS,G,TIME,MDEC,COLLF,DTCTF,CHDOV,SHDOV,CPSI,SPSI,
     *     FHX,FHY,FHZ,THX,THY,THZ,BETA,HEAD,VTOT,VX,VY,ATOT,AX,AY,
     1     UH1,VH1,WH1,Z1,FX1,FY1,FN1,BET1,FC1,FS1,
     2     UH2,VH2,WH2,Z2,FX2,FY2,FN2,BET2,FC2,FS2,
     3     UH3,VH3,WH3,Z3,FX3,FY3,FN3,BET3,FC3,FS3,
     4     UH4,VH4,WH4,Z4,FX4,FY4,FN4,BET4,FC4,FS4
C
      TAN(X) = SIN(X)/COS(X)
C
      IF(MODE .NE. 0) GO TO 100
C
C*****INITIALIZATION*****
C
```

FIGURE B-6. SUBROUTINE VEH3 PROGRAM LISTING

```
      MASS = WEIGHT/G
      WB = DF + DR
      T1 = 0.5*WEIGHT/WB
      WF = T1*DR
      WR = T1*DF
      ZHF = ZF + HF
      ZHR = ZR + HR
      HCG = (ZHF*DF + ZHR*DR)/WB
C
      BETSF = BETASF*DEGRAD
      BETSR = BETASR*DEGRAD
      SMUXF = SNR*MUXF
      SMUXR = SNR*MUXR
      SMUYF = SNR*MUYF
      SMUYR = SNR*MUYR
      ROFSQ = (SMUYF/SMUXF)**2
      RORSQ = (SMUYR/SMUXR)**2
      CSF = 1.5*SMUYF/BETSF
      CSR = 1.5*SMUYR/BETSR
      KSTAB = (1.0/CSF - 1.0/CSR)/(G*WB)
      GCSR = G*CSR
      UTH = 2.0*GCSR*DT
      VTH = 2.0*G*DT*(SMUYF*DR + SMUYR*DF)/WB
      HR2 = 2.0*HR
C
      WDF = 0.5*WEIGHT*DF
      WDR = 0.5*WEIGHT*DR
      KBHF = KBF/HF
      KBHR = KBR/HR
      KBHCF = KBHF*HCG
      KBHCR = KBHR*HCG
      KBHCG = KBHCF + KBHCR
C
      MUXHCF = SMUXF*HCG
      MUXHCR = SMUXR*HCG
      DENOM = WB - MUXHCF + MUXHCR
      TEMP = 0.5*WEIGHT/DENOM
      FBFMX = SMUXF*TEMP*(DR + MUXHCR)
      FBRMX = SMUXR*TEMP*(DF - MUXHCF)
      FBMAX = 2.0*(FBFMX + FBRMX)
      DBPMAX = AMAX1(FBFMX/KBHF,FBRMX/KBHR)
C
      RETURN
C
C*****IN THE LOOP*****
C
C COMPUTE STEERING, BRAKING, AND DRIVE FORCES
C
  100 DELW = KSW*DEGRAD*DELSW
      DELBP = DELB*DBPMAX
      FT = 0
      IF(DELB .EQ. 0.0) FT = AMIN1(-KSC*(UH-UCMD),TDMAX)/HR2
      FBF = KBHF*DELBP
      FBR = KBHR*DELBP
      CDELW = COS(DELW)
      SDELW = SIN(DELW)
C
C COMPUTE VELOCITIES AND FORCES AT EACH WHEEL
C
C     LONGITUDINAL WHEEL VELOCITIES IN HORIZONTAL BODY FRAME
```

FIGURE B-6. (continued)

```
      UF = WZ*TF
      UR = WZ*TR
      UH1 = UH - UF
      UH2 = UH + UF
      UH3 = UH - UR
      UH4 = UH + UR
C
C     LATERAL WHEEL VELOCITIES IN HORIZONTAL BODY FRAME
      VF = WZ*DF
      VR = WZ*DR
      VH1 = VH + VF
      VH2 = VH1
      VH3 = VH - VR
      VH4 = VH3
C
C     TIRE SIDESLIP
      BET1 = ATAN(VH1/AMAX1(ABS(UH1),0.001)) - DELW*SIGN(1.0,UH1)
      BET2 = ATAN(VH2/AMAX1(ABS(UH2),0.001)) - DELW*SIGN(1.0,UH2)
      BET3 = ATAN(VH3/AMAX1(ABS(UH3),0.001))
      BET4 = ATAN(VH4/AMAX1(ABS(UH4),0.001))
C
      BETN1 = SIGN(AMIN1(ABS(BET1/BETSF),1.0),BET1)
      BETN2 = SIGN(AMIN1(ABS(BET2/BETSF),1.0),BET2)
      BETN3 = SIGN(AMIN1(ABS(BET3/BETSR),1.0),BET3)
      BETN4 = SIGN(AMIN1(ABS(BET4/BETSR),1.0),BET4)
C
      TBET1 = TAN(BET1)
      TBET2 = TAN(BET2)
      TBET3 = TAN(BET3)
      TBET4 = TAN(BET4)
C
      FNX = 0.5*FHX*HCG/WB
      TEMP = 0.5*FHY*HCG/(KF+KR)
      FNYF = KF*TEMP/TF
      FNYR = KR*TEMP/TR
C
C     NORMAL TIRE FORCES
      FN1 = WF - FNX - FNYF
      FN2 = WF - FNX + FNYF
      FN3 = WR + FNX - FNYR
      FN4 = WR + FNX + FNYR
C
      FMY1 = SMUYF*FN1
      FMY2 = SMUYF*FN2
      FMY3 = SMUYR*FN3
      FMY4 = SMUYR*FN4
C
      FCM1 = FMY1/SQRT(ROFSQ + TBET1**2)
      FCM2 = FMY2/SQRT(ROFSQ + TBET2**2)
      FCM3 = FMY3/SQRT(RORSQ + TBET3**2)
      FCM4 = FMY4/SQRT(RORSQ + TBET4**2)
C
C     CIRCUMFERENTIAL TIRE FORCES
      FC1 = -SIGN(AMIN1(FBF,FCM1),UH1)
      FC2 = -SIGN(AMIN1(FBF,FCM2),UH2)
      FC3 = -SIGN(AMIN1(FBR,FCM3),UH3) + AMIN1(FT,SMUXR*FN3)
      FC4 = -SIGN(AMIN1(FBR,FCM4),UH4) + AMIN1(FT,SMUXR*FN4)
C
      FSM1 = SQRT(ABS(FMY1**2 - ROFSQ*FC1**2))
      FSM2 = SQRT(ABS(FMY2**2 - ROFSQ*FC2**2))
      FSM3 = SQRT(ABS(FMY3**2 - RORSQ*FC3**2))
```

FIGURE B-6. (continued)

```
      FSM4 = SQRT(ABS(FMY4**2 - RORSQ*FC4**2))
C
C     SIDE TIRE FORCES
      FS1 = 0.5*BETN1*(3.0 - BETN1**2)*FMY1 + FBF*TBET1
      FS2 = 0.5*BETN2*(3.0 - BETN2**2)*FMY2 + FBF*TBET2
      FS3 = 0.5*BETN3*(3.0 - BETN3**2)*FMY3 + FBR*TBET3
      FS4 = 0.5*BETN4*(3.0 - BETN4**2)*FMY4 + FBR*TBET4
C
      FS1 = -SIGN(AMIN1(ABS(FS1),FSM1),BET1)
      FS2 = -SIGN(AMIN1(ABS(FS2),FSM2),BET2)
      FS3 = -SIGN(AMIN1(ABS(FS3),FSM3),BET3)
      FS4 = -SIGN(AMIN1(ABS(FS4),FSM4),BET4)
C
C     LONGITUDINAL TIRE FORCES
      FX1 = FC1*CDELW - FS1*SDELW
      FX2 = FC2*CDELW - FS2*SDELW
      FX3 = FC3
      FX4 = FC4
C
C     LATERAL TIRE FORCES
      FY1 = FC1*SDELW + FS1*CDELW
      FY2 = FC2*SDELW + FS2*CDELW
      FY3 =             FS3
      FY4 =             FS4
C
C COMPUTE TOTAL FORCES AND MOMENTS IN HORIZONTAL PLANE
C
      FHX = FX1 + FX2 + FX3 + FX4
      FHY = FY1 + FY2 + FY3 + FY4
C
      THZ = TF*(FX2-FX1) + TR*(FX4-FX3) + DF*(FY1+FY2) - DR*(FY3+FY4)
C
      IF(ABS(UH) .GT. UTH .OR. ABS(VH) .GT. VTH) GO TO 150
C
C UPDATE STATE DERIVATIVES FOR VELOCITIES BELOW THRESHOLD
C
      WZ = UH*DELW/(WB*(1.0 + KSTAB*UH**2))
      WZD = 0
      PSID = WZ
C
      VH = (1.0 - UH/GCSR)*DR*PSID
      UHD = PSID*VH + FHX/MASS
      VHD = 0
      GO TO 200
C
C UPDATE YAW RATE AND ATTITUDE DERIVATIVES IN BODY FRAME
C
  150 WZD = THZ/IZZ
      PSID = WZ
C
C UPDATE VELOCITY DERIVATIVES IN HORIZONTAL PLANE
C
      UHD = PSID*VH + FHX/MASS
      VHD =-PSID*UH + FHY/MASS
C
C UPDATE POSITION DERIVATIVES IN INERTIAL FRAME
C
  200 XD = CPSI*UH - SPSI*VH
      YD = SPSI*UH + CPSI*VH
      RETURN
      END
```

FIGURE B-6. (concluded)

```
      SUBROUTINE VEH2(MODE)
C
C 2 DOF LATERAL-AXIS VEHICLE MODEL
C
      REAL IXX,IYY,IZZ,KF,KR,MUXF,MUXR,MUYF,MUYR,KSW,KBF,KBR,KSC
      REAL LW
      REAL LSVF,LSVR,LOV
      REAL IO,IB,LSKY,LSUR,KL,KV1,KV2
      REAL MPHFPS,MANDEC,LAV,LF,LR
      INTEGER COLLF,DTCTF
      REAL NV,NR,NDW,KSTAB
C
      COMMON /STATES/
     1     UH,VH,WH,X,Y,Z,
     2     WX,WY,WZ,PHI,THE,PSI,
     3     UOV,XOV,ULV,XLV,UNV,XNV
C
      COMMON /DERIVS/
     1     UHD,VHD,WHD,XD,YD,ZD,
     2     WXD,WYD,WZD,PHID,THED,PSID,
     3     UOVD,XOVD,ULVD,XLVD,UNVD,XNVD
C
      COMMON /CONT/ DELSW,DELB
C
      COMMON /PARAM/
     1     UHO,VHO,WHO,XO,YO,ZO,
     2     WXO,WYO,WZO,PHIO,THEO,PSIO,
     3     WEIGHT,IXX,IYY,IZZ,
     4     DF,DR,TF,TR,ZF,ZR,HF,HR,
     5     KF,KR,CF,CR,
     6     MUXF,MUXR,MUYF,MUYR,BETASF,BETASR,SNR,
     7     KSW,KBF,KBR,
     8     KSC,UCMD,TDMAX,
     9     MANDEC,TAUR,TAUP,WC,VETH,YETH,
     A     ABR,ABSTB,ABSTC,ASWS,ASWC,TSW,SWMAX,SWRMAX,
     B     HOV,UOVO,DOVG,HLV,ULVO,DLVG,HNVMIN,HNVAVE,UNVO,DISTSO,DISTNS,
     C     PSIB,LW,TAUD,TAUOVD,
     D     LAV,HAVMIN,HAVAVE,LF,LR,PBO,PSO,PA,TTHRSH,DTHRSH,TLOOK,
     E     ESKY,ESUN,RO,EO,IO,BSUNO,RB,EB,IB,BSUNB,LSKY,LSUR,
     F     TRANS,KL,VO,HO,PLITE,HRTH,HPER,SIGC,KV1,KV2,ALPHMN,
     G     HEYE,HLITE,HOBJ,TAUBM,TAUBS,TAURDM,TAURDS,
     H     LSVF,LSVR,WSV,LOV,WOV,UHTH,VHTH
C
      COMMON
     *     MSCEN,MNITE,MDET,MADJ,MVEH,MSTOR,MPRT,
     *     NU,NX,NVAR,NTRIAL,ISEED,DT,DTPRT,DTSTOR,TMAX,
     *     DEGRAD,MPHFPS,G,TIME,MDEC,COLLF,DTCTF,CHDOV,SHDOV,CPSI,SPSI,
     *     FHX,FHY,FHZ,THX,THY,THZ,BETA,HEAD,VTOT,VX,VY,ATOT,AX,AY,
     1     UH1,VH1,WH1,Z1,FX1,FY1,FN1,BET1,FC1,FS1,
     2     UH2,VH2,WH2,Z2,FX2,FY2,FN2,BET2,FC2,FS2,
     3     UH3,VH3,WH3,Z3,FX3,FY3,FN3,BET3,FC3,FS3,
     4     UH4,VH4,WH4,Z4,FX4,FY4,FN4,BET4,FC4,FS4
C
      IF(MODE .NE. 0) GO TO 100
C
C*****INITIALIZATION*****
C
      WB = DF + DR
      DFDR = DF*DR/WB
      WIZZ = WEIGHT/IZZ
      GUO = G/UHO
```

FIGURE B-7. SUBROUTINE VEH2 PROGRAM LISTING

```
      WIZZUO = WIZZ/UHO
      BETSF = BETASF*DEGRAD
      BETSR = BETASR*DEGRAD
      SMUYF = SNR*MUYF
      SMUYR = SNR*MUYR
      CSF = 1.5*SMUYF/BETSF
      CSR = 1.5*SMUYR/BETSR
C
      YV = -GUO*DFDR*(CSF/DF + CSR/DR)
      YR = -GUO*DFDR*(CSF - CSR)
      YDW = G*DR*CSF/WB
      NV = -WIZZUO*DFDR*(CSF - CSR)
      NR = -WIZZUO*DFDR*(DF*CSF + DR*CSR)
      NDW = WIZZ*DFDR*CSF
      YRMUO = YR - UHO
C
      GCSR = G*CSR
      KSTAB = (1.0/CSF - 1.0/CSR)/(G*WB)
      GRDW = UHO/(WB*(1.0 + KSTAB*UHO**2))
      GVDW = (1.0 - UHO/GCSR)*DR*GRDW
      UTH = 2.0*GCSR*DT
C
      UHD = 0
C
      RETURN
C
C*****IN THE LOOP*****
C
  100 DELW = KSW*DEGRAD*DELSW
      IF(ABS(UH) .GT. UTH) GO TO 150
C
C COMPUTE STEADY-STATE LATERAL VELOCITY AND YAW RATE IN BODY FRAME
C
      VHD = 0
      WZD = 0
      VH = GVDW*DELW
      WZ = GRDW*DELW
      GO TO 200
C
C UPDATE LATERAL VELOCITY AND YAW RATE DERIVATIVES
C
  150 VHD = YV*VH + YRMUO*WZ + YDW*DELW
      WZD = NV*VH + NR   *WZ + NDW*DELW
C
C UPDATE LONGITUDINAL, LATERAL POSITION AND YAW ATTITUDE DERIVATIVES
C
  200 XD = CPSI*UH - SPSI*VH
      YD = SPSI*UH + CPSI*VH
      PSID = WZ
C
      RETURN
      END
```

FIGURE B-7. (concluded)

```
      SUBROUTINE VEH1(MODE)
C
C 1 DOF LONGITUDINAL-AXIS VEHICLE MODEL
C
      REAL IXX,IYY,IZZ,KF,KR,MUXF,MUXR,MUYF,MUYR,KSW,KBF,KBR,KSC
      REAL LW
      REAL LSVF,LSVR,LOV
      REAL IO,IB,LSKY,LSUR,KL,KV1,KV2
      REAL MPHFPS,MANDEC,LAV,LF,LR
      INTEGER COLLF,DTCTF
      REAL MASS,KBHF,KBHR,KBHCF,KBHCR,KBHCG,MUXHCF,MUXHCR
C
      COMMON /STATES/
     1     UH,VH,WH,X,Y,Z,
     2     WX,WY,WZ,PHI,THE,PSI,
     3     UOV,XOV,ULV,XLV,UNV,XNV
C
      COMMON /DERIVS/
     1     UHD,VHD,WHD,XD,YD,ZD,
     2     WXD,WYD,WZD,PHID,THED,PSID,
     3     UOVD,XOVD,ULVD,XLVD,UNVD,XNVD
C
      COMMON /CONT/ DELSW,DELB
C
      COMMON /PARAM/
     1     UHO,VHO,WHO,XO,YO,ZO,
     2     WXO,WYO,WZO,PHIO,THEO,PSIO,
     3     WEIGHT,IXX,IYY,IZZ,
     4     DF,DR,TF,TR,ZF,ZR,HF,HR,
     5     KF,KR,CF,CR,
     6     MUXF,MUXR,MUYF,MUYR,BETASF,BETASR,SNR,
     7     KSW,KBF,KBR,
     8     KSC,UCMD,TDMAX,
     9     MANDEC,TAUR,TAUP,WC,VETH,YETH,
     A     ABR,ABSTB,ABSTC,ASWS,ASWC,TSW,SWMAX,SWRMAX,
     B     HOV,UOVO,DOVG,HLV,ULVO,DLVG,HNVMIN,HNVAVE,UNVO,DISTSO,DISTNS,
     C     PSIB,LW,TAUD,TAUOVD,
     D     LAV,HAVMIN,HAVAVE,LF,LR,PBO,PSO,PA,TTHRSH,DTHRSH,TLOOK,
     E     ESKY,ESUN,RO,EO,IO,BSUNO,RB,EB,IB,BSUNB,LSKY,LSUR,
     F     TRANS,KL,VO,HO,PLITE,HRTH,HPER,SIGC,KV1,KV2,ALPHMN,
     G     HEYE,HLITE,HOBJ,TAUBM,TAUBS,TAURDM,TAURDS,
     H     LSVF,LSVR,WSV,LOV,WOV,UHTH,VHTH
C
      COMMON
     *     MSCEN,MNITE,MDET,MADJ,MVEH,MSTOR,MPRT,
     *     NU,NX,NVAR,NTRIAL,ISEED,DT,DTPRT,DTSTOR,TMAX,
     *     DEGRAD,MPHFPS,G,TIME,MDEC,COLLF,DTCTF,CHDOV,SHDOV,CPSI,SPSI,
     *     FHX,FHY,FHZ,THX,THY,THZ,BETA,HEAD,VTOT,VX,VY,ATOT,AX,AY,
     1     UH1,VH1,WH1,Z1,FX1,FY1,FN1,BET1,FC1,FS1,
     2     UH2,VH2,WH2,Z2,FX2,FY2,FN2,BET2,FC2,FS2,
     3     UH3,VH3,WH3,Z3,FX3,FY3,FN3,BET3,FC3,FS3,
     4     UH4,VH4,WH4,Z4,FX4,FY4,FN4,BET4,FC4,FS4
C
      IF(MODE .NE. 0) GO TO 100
C
C*****INITIALIZATION*****
C
      MASS = WEIGHT/G
      WB = DF + DR
      WDF = 0.5*WEIGHT*DF
      WDR = 0.5*WEIGHT*DR
```

FIGURE B-8. SUBROUTINE VEH1 PROGRAM LISTING

```
C
      ZHF = ZF + HF
      ZHR = ZR + HR
      HCG = (ZHF*DF + ZHR*DR)/WB
      KBHF = KBF/HF
      KBHR = KBR/HR
      KBHCF = KBHF*HCG
      KBHCR = KBHR*HCG
      KBHCG = KBHCF + KBHCR
C
      SMUXF = SNR*MUXF
      SMUXR = SNR*MUXR
      MUXHCF = SMUXF*HCG
      MUXHCR = SMUXR*HCG
      DENOMF = WB - MUXHCF
      DENOMR = WB + MUXHCR
      DENOM = WB - MUXHCF + MUXHCR
      TEMP = 0.5*WEIGHT/DENOM
      FBFMX = SMUXc*TEMP*(DR + MUXHCR)
      FBRMX = SMUXR*TEMP*(DF - MUXHCF)
      FBMAX = 2.0*(FBFMX + FBRMX)
C
      DBFTH = WDR/(KBHF*WB/SMUXF - KBHCG)
      DBRTH = WDF/(KBHR*WB/SMUXR + KBHCG)
      DBPMIN = AMIN1(DBFTH,DBRTH)
      DBPMAX = AMAX1(FBFMX/KBHF,FBRMX/KBHR)
C
      RETURN
C
C*****IN THE LOOP*****
C
C COMPUTE LONGITUDINAL FORCE DUE TO BRAKING
C
  100 DELBP = DELB*DBPMAX
      FBF = KBHF*DELBP
      FBR = KBHR*DELBP
      IF(DELBP .GT. DBPMIN) GO TO 110
C
C     NO WHEELS LOCKED
      FHX = -SIGN(2.0*(FBF+FBR),UH)
      GO TO 150
C
  110 IF(DELBP .GE. DBPMAX) GO TO 140
      IF(DBFTH - DBRTH) 120, 130, 130
C
C     FRONT WHEELS LOCKED
  120 FHX = -SIGN(2.0*(WDR*SMUXF + FBR*WB)/DENOMF,UH)
      GO TO 150
C
C     REAR WHEELS LOCKED
  130 FHX = -SIGN(2.0*(WDF*SMUXR + FBF*WB)/DENOMR,UH)
      GO TO 150
C
C     ALL WHEELS LOCKED
  140 FHX = -SIGN(FBMAX,UH)
  150 CONTINUE
C
C UPDATE LONGITUDINAL VELOCITY AND POSITION DERIVATIVES
C
      UHD = FHX/MASS
      XD = UH
C
      RETURN
      END
```

FIGURE B-8. (concluded)

```
      SUBROUTINE DRIVER(MODE)
C
C     DRIVER CONTROL MODEL
C
      REAL IXX,IYY,IZZ,KF,KR,MUXF,MUXR,MUYF,MUYR,KSW,KBF,KBR,KSC
      REAL LW
      REAL LSVF,LSVR,LOV
      REAL IO,IB,LSKY,LSUR,KL,KV1,KV2
      REAL MPHFPS,MANDEC,LAV,LF,LR
      INTEGER COLLF,DTCTF
      REAL KPSI,KY
      DIMENSION VES(100),YES(100),PSILS(100)
C
      COMMON /STATES/
     1      UH,VH,WH,X,Y,Z,
     2      WX,WY,WZ,PHI,THE,PSI,
     3      UOV,XOV,ULV,XLV,UNV,XNV
C
      COMMON /DERIVS/
     1      UHD,VHD,WHD,XD,YD,ZD,
     2      WXD,WYD,WZD,PHID,THED,PSID,
     3      UOVD,XOVD,ULVD,XLVD,UNVD,XNVD
C
      COMMON /CONT/ DELSW,DELB
C
      COMMON /PARAM/
     1      UHO,VHO,WHO,XO,YO,ZO,
     2      WXO,WYO,WZO,PHIO,THEO,PSIO,
     3      WEIGHT,IXX,IYY,IZZ,
     4      DF,DR,TF,TR,ZF,ZR,HF,HR,
     5      KF,KR,CF,CR,
     6      MUXF,MUXR,MUYF,MUYR,BETASF,BETASR,SNR,
     7      KSW,KBF,KBR,
     8      KSC,UCMD,TDMAX,
     9      MANDEC,TAUR,TAUP,WC,VETH,YETH,
     A      ABR,ABSTB,ABSTC,ASWS,ASWC,TSW,SWMAX,SWRMAX,
     B      HOV,UOVO,DOVG,HLV,ULVO,DLVG,HNVMIN,HNVAVE,UNVO,DISTSO,DISTNS,
     C      PSIB,LW,TAUD,TAUOVD,
     D      LAV,HAVMIN,HAVAVE,LF,LR,PBO,PSO,PA,TTHRSH,DTHRSH,TLOOK,
     E      ESKY,ESUN,RO,EO,IO,BSUNO,RB,EB,IB,BSUNB,LSKY,LSUR,
     F      TRANS,KL,VO,HO,PLITE,HRTH,HPER,SIGC,KV1,KV2,ALPHMN,
     G      HEYE,HLITE,HOBJ,TAUBM,TAUBS,TAURDM,TAURDS,
     H      LSVF,LSVR,WSV,LOV,WOV,UHTH,VHTH
C
      COMMON
     *      MSCEN,MNITE,MDET,MADJ,MVEH,MSTOR,MPRT,
     *      NU,NX,NVAR,NTRIAL,ISEED,DT,DTPRT,DTSTOR,TMAX,
     *      DEGRAD,MPHFPS,G,TIME,MDEC,COLLF,DTCTF,CHDOV,SHDOV,CPSI,SPSI,
     *      FHX,FHY,FHZ,THX,THY,THZ,BETA,HEAD,VTOT,VX,VY,ATOT,AX,AY,
     1      UH1,VH1,WH1,Z1,FX1,FY1,FN1,BET1,FC1,FS1,
     2      UH2,VH2,WH2,Z2,FX2,FY2,FN2,BET2,FC2,FS2,
     3      UH3,VH3,WH3,Z3,FX3,FY3,FN3,BET3,FC3,FS3,
     4      UH4,VH4,WH4,Z4,FX4,FY4,FN4,BET4,FC4,FS4
C
      IF(MODE .NE. 0) GO TO 100
C
C*****INITIALIZATION*****
C
      PI = 4.0*ATAN(1.0)
C
```

FIGURE B-9. <u>SUBROUTINE DRIVER</u> PROGRAM LISTING

```
      KDEL = TAUR/AMAX1(DT,0.001) + 0.5
      IF(KDEL .EQ. 0) GO TO 15
      KDEL = MINO(KDEL,100)
      DO 10 K = 1, KDEL
      VES(K) = 0
      YES(K) = 0
   10 PSILS(K) = 0
   15 K = 0
      YCMD = -LW
      IF(SHDOV .EQ. -1.0) YCMD = LW
C
      ALFP=1.0/TAUP
      GPSI = WC*(DF+DR)/KSW
      GCSR = 1.5*G*SNR*MUYR/(BETASR*DEGRAD)
      TLTH = 2.0*DT
      WSW = 2.0*PI/TSW
      SWDMAX = SWRMAX*DT
C
      TIMEB = 0
      TIMES = 0
      DELSW = 0
      DELSWP = 0
      DELB = 0
      UHI = AMAX1(UH,0.001)
      RETURN
C
C*****IN THE LOOP*****
C
C PERCEPTION/DECISION MODE: SET MANEUVER COMMANDS
C
  100 GO TO (160,170,180), MDEC
C
C       BRAKING MANEUVER (MDEC = 1)
  160 VXC = 0
      YC = 0
      ABST = ABSTB
      GO TO 200
C
C       STEERING MANEUVER (MDEC = 2)
  170 VXC = VX
      YC = YCMD
      ASW = ASWS
      GO TO 200
C
C       BRAKING AND STEERING MANEUVER (MDEC = 3)
  180 VXC = 0
      YC = YCMD
      ABST = ABSTC
      ASW = ASWC
C
C TIME DELAY PHASE
C
  200 CONTINUE
      TL = UH/GCSR
      IF(TL .LT. TLTH) TL = 0
      IF(KDEL .EQ. 0) GO TO 210
      K = MOD(K,KDEL) + 1
      VE = VES(K)
      YE = YES(K)
      PSIL = PSILS(K)
```

FIGURE B-9. (continued)

```
      VES(K) = VXC - VX
      YES(K) = YC - Y
      PSILS(K) = PSI + TL*WZ
      GO TO 220
C
  210 VE = VXC - VX
      YE = YC - Y
      PSIL = PSI + TL*WZ
C
  220 IF(ABS(VE) .LT. VETH .AND. ABS(YE) .LT. YETH) GO TO 300
C
C RAPID RESPONSE PHASE (OPEN-LOOP)
C
C     BRAKING INPUT
  230 IF(MDEC .EQ. 2) GO TO 240
      DELB = AMIN1(ABR*TIMEB,ABST)
      IF(ABR .EQ. 0.0) DELB = ABST
      TIMEB = TIMEB + DT
C
C     STEERING INPUT
  240 IF(MDEC .EQ. 1) GO TO 300
      IF(TIMES .GT. TSW) GO TO 300
      DELSW = SIGN(ASW,YC)*SIN(WSW*TIMES)
      TIMES = TIMES + DT*UH/UHI
      RETURN
C
C ERROR REDUCTION PHASE (CLOSED-LOOP)
C
  300 UHL = AMAX1(UH,UHTH)
      KPSI = GPSI/UHL
      KY = ALFP/UHL
      PSIC = KY*YE
      DELSW = KPSI*(PSIC - PSIL)/DEGRAD
      DELSW = SIGN(AMIN1(ABS(DELSW),SWMAX),DELSW)
      DELSWD = DELSW - DELSWP
      IF(ABS(DELSWD) .GT. SWDMAX) DELSW = DELSWP + SIGN(SWDMAX,DELSWD)
      DELSWP = DELSW
      DELB = DELB*AMIN1(ABS(UH/UHTH),1.0)
      RETURN
      END
```

FIGURE B-9. (concluded)

```
      SUBROUTINE COLL(MODE)
C
C     COLLISION DETERMINATION ALGORITHM
C
      REAL IXX,IYY,IZZ,KF,KR,MUXF,MUXR,MUYF,MUYR,KSW,KBF,KBR,KSC
      REAL LW
      REAL LSVF,LSVR,LOV
      REAL IO,IB,LSKY,LSUR,KL,KV1,KV2
      REAL MPHFPS,MANDEC,LAV,LF,LR
      INTEGER COLLF,DTCTF
      REAL LSVH,LOVH,LSVFC,LSVRC,LSVFS,LSVRS
C
      COMMON /STATES/
     1     UH,VH,WH,X,Y,Z,
     2     WX,WY,WZ,PHI,THE,PSI,
     3     UOV,XOV,ULV,XLV,UNV,XNV
C
      COMMON /DERIVS/
     1     UHD,VHD,WHD,XD,YD,ZD,
     2     WXD,WYD,WZD,PHID,THED,PSID,
     3     UOVD,XOVD,ULVD,XLVD,UNVD,XNVD
C
      COMMON /CONT/ DELSW,DELB
C
      COMMON /PARAM/
     1     UHO,VHO,WHO,XO,YO,ZO,
     2     WXO,WYO,WZO,PHIO,THEO,PSIO,
     3     WEIGHT,IXX,IYY,IZZ,
     4     DF,DR,TF,TR,ZF,ZR,HF,HR,
     5     KF,KR,CF,CR,
     6     MUXF,MUXR,MUYF,MUYR,BETASF,BETASR,SNR,
     7     KSW,KBF,KBR,
     8     KSC,UCMD,TDMAX,
     9     MANDEC,TAUR,TAUP,WC,VETH,YETH,
     A     ABR,ABSTB,ABSTC,ASWS,ASWC,TSW,SWMAX,SWRMAX,
     B     HOV,UOVO,DOVG,HLV,ULVO,DLVG,HNVMIN,HNVAVE,UNVO,DISTSO,DISTNS,
     C     PSIB,LW,TAUD,TAUOVD,
     D     LAV,HAVMIN,HAVAVE,LF,LR,PBO,PSO,PA,TTHRSH,DTHRSH,TLOOK,
     E     ESKY,ESUN,RO,EO,IO,BSUNO,RB,EB,IB,BSUNB,LSKY,LSUR,
     F     TRANS,KL,VO,HO,PLITE,HRTH,HPER,SIGC,KV1,KV2,ALPHMN,
     G     HEYE,HLITE,HOBJ,TAUBM,TAUBS,TAURDM,TAURDS,
     H     LSVF,LSVR,WSV,LOV,WOV,UHTH,VHTH
C
      COMMON
     *     MSCEN,MNITE,MDET,MADJ,MVEH,MSTOR,MPRT,
     *     NU,NX,NVAR,NTRIAL,ISEED,DT,DTPRT,DTSTOR,TMAX,
     *     DEGRAD,MPHFPS,G,TIME,MDEC,COLLF,DTCTF,CHDOV,SHDOV,CPSI,SPSI,
     *     FHX,FHY,FHZ,THX,THY,THZ,BETA,HEAD,VTOT,VX,VY,ATOT,AX,AY,
     1     UH1,VH1,WH1,Z1,FX1,FY1,FN1,BET1,FC1,FS1,
     2     UH2,VH2,WH2,Z2,FX2,FY2,FN2,BET2,FC2,FS2,
     3     UH3,VH3,WH3,Z3,FX3,FY3,FN3,BET3,FC3,FS3,
     4     UH4,VH4,WH4,Z4,FX4,FY4,FN4,BET4,FC4,FS4
C
      IF(MODE .NE. 0) GO TO 100
C
C*****INITIALIZATION*****
C
      LOVH = 0.5*LOV
      WOVH = 0.5*WOV
      LSVH = 0.5*(LSVF+LSVR)
      WSVH = 0.5*WSV
```

FIGURE B-10. SUBROUTINE COLL PROGRAM LISTING

```
      YOV = 0
      XMIN = LSVR + LOVH
C
C EXIT IF COLLISION OCCURS BEFORE EVASIVE MANEUVER BEGINS
C
      IF(MSCEN .GE. 6) GO TO 10
      IF(X+LSVF .GE. XOV-LOVH) GO TO 160
      RETURN
   10 IF(MSCEN .GE. 9) GO TO 20
      IF(X+LSVF .GE. 0.0 .AND. XOV+LOVH .GE. 0.0) GO TO 160
      RETURN
   20 LOVH = 0.5*HO
      WOVH = LOVH
      IF(X+LSVF .GE. -LOVH) GO TO 160
      RETURN
C
C*****IN THE LOOP*****
C
  100 CONTINUE
C
C EXIT IF SV SPEED IS LESS THAN THRESHOLD OR SV AHEAD OF OV (NO COLL.)
C
      DELXSV = X*CHDOV + Y*SHDOV - XOV
      DELYSV =-X*SHDOV + Y*CHDOV - YOV
      IF(ABS(UH) .LT. UHTH .AND. ABS(VH) .LT. VHTH) GO TO 170
      IF(DELXSV .GT. XMIN) GO TO 170
C
C EXIT IF A CORNER OF SV LIES WITHIN OV (COLLISION)
C
      CPSIR = CPSI*CHDOV + SPSI*SHDOV
      SPSIR =-CPSI*SHDOV + SPSI*CHDOV
      LSVFC = LSVF*CPSIR
      LSVFS = LSVF*SPSIR
      LSVRC = LSVR*CPSIR
      LSVRS = LSVR*SPSIR
      WSVHC = WSVH*CPSIR
      WSVHS = WSVH*SPSIR
C
C     RIGHT FRONT
      XSVRF = DELXSV + LSVFC - WSVHS
      YSVRF = DELYSV + LSVFS + WSVHC
      IF(ABS(XSVRF) .LE. LOVH .AND. ABS(YSVRF) .LE. WOVH) GO TO 160
C
C     LEFT FRONT
      XSVLF = DELXSV + LSVFC + WSVHS
      YSVLF = DELYSV + LSVFS - WSVHC
      IF(ABS(XSVLF) .LE. LOVH .AND. ABS(YSVLF) .LE. WOVH) GO TO 160
C
C     RIGHT REAR
      XSVRR = DELXSV - LSVRC - WSVHS
      YSVRR = DELYSV - LSVRS + WSVHC
      IF(ABS(XSVRR) .LE. LOVH .AND. ABS(YSVRR) .LE. WOVH) GO TO 160
C
C     LEFT REAR
      XSVLR = DELXSV - LSVRC + WSVHS
      YSVLR = DELYSV - LSVRS - WSVHC
      IF(ABS(XSVLR) .LE. LOVH .AND. ABS(YSVLR) .LE. WOVH) GO TO 160
C
C EXIT IF A CORNER OF OV LIES WITHIN SV (COLLISION)
C
      DELXOV = XOV*CHDOV - YOV*SHDOV - X - 0.5*(LSVF-LSVR)
```

FIGURE B-10. (continued)

```
      DELYOV = XOV*SHDOV + YOV*CHDOV - Y
C
      LOVHC = LOVH*CPSIR
      LOVHS =-LOVH*SPSIR
      WOVHC = WOVH*CPSIR
      WOVHS =-WOVH*SPSIR
C
C     RIGHT FRONT
      XOVRF = DELXOV + LOVHC - WOVHS
      YOVRF = DELYOV + LOVHS + WOVHC
      IF(ABS(XOVRF) .LE. LSVH .AND. ABS(YOVRF) .LE. WSVH) GO TO 160
C
C     LEFT FRONT
      XOVLF = DELXOV + LOVHC + WOVHS
      YOVLF = DELYOV + LOVHS - WOVHC
      IF(ABS(XOVLF) .LE. LSVH .AND. ABS(YOVLF) .LE. WSVH) GO TO 160
C
C     RIGHT REAR
      XOVRR = DELXOV - LOVHC - WOVHS
      YOVRR = DELYOV - LOVHS + WOVHC
      IF(ABS(XOVRR) .LE. LSVH .AND. ABS(YOVRR) .LE. WSVH) GO TO 160
C
C     LEFT REAR
      XOVLR = DELXOV - LOVHC + WOVHS
      YOVLR = DELYOV - LOVHS - WOVHC
      IF(ABS(XOVLR) .LE. LSVH .AND. ABS(YOVLR) .LE. WSVH) GO TO 160
      RETURN
C
C SET COLLISION FLAG
C
C     COLLISION HAS OCCURED
  160 COLLF = 1
      RETURN
C
C     NO COLLISION POSSIBLE
  170 COLLF = 0
      RETURN
      END
```

FIGURE B-10. (concluded)

```
      SUBROUTINE DATAIO(MODE)
C
C     DATA INPUT ROUTINE
C
      REAL IXX,IYY,IZZ,KF,KR,MUXF,MUXR,MUYF,MUYR,KSW,KBF,KBR,KSC
      REAL LW
      REAL LSVF,LSVR,LOV
      REAL IO,IB,LSKY,LSUR,KL,KV1,KV2
      REAL MPHFPS,MANDEC,LAV,LF,LR
      INTEGER COLLF,DTCTF
      REAL*4 IOFLAG
      REAL*8 LAB
      REAL*8 LABX, LABU, LABY, LABP, BUFF, SCLAB
C
      DIMENSION PAR(118)
C
      COMMON /INPUT/
     *    NIVG,NSTOR,NRV,L(3),NIV(3),NO(3),INDEX(50),NPT(50),
     *    IRV(50),IRVT(50),RV(50),RVMIN(50),RVMAX(50),
     *    RVS1(50),RVS2(50),PS(11,50),XS(11,50),PLIST(50,10),
     *    RVM(50),RVS(50),LABX(18),LABU(2),LABY(56),LABP(118),
     *    SCLAB(10,12),BUFF(10)
C
      COMMON /STATES/
     1    UH,VH,WH,X,Y,Z,
     2    WX,WY,WZ,PHI,THE,PSI,
     3    UOV,XOV,ULV,XLV,UNV,XNV
C
      COMMON /DERIVS/
     1    UHD,VHD,WHD,XD,YD,ZD,
     2    WXD,WYD,WZD,PHID,THED,PSID,
     3    UOVD,XOVD,ULVD,XLVD,UNVD,XNVD
C
      COMMON /CONT/ DELSW,DELB
C
      COMMON /PARAM/
     1    UHO,VHO,WHO,XO,YO,ZO,
     2    WXO,WYO,WZO,PHIO,THEO,PSIO,
     3    WEIGHT,IXX,IYY,IZZ,
     4    DF,DR,TF,TR,ZF,ZR,HF,HR,
     5    KF,KR,CF,CR,
     6    MUXF,MUXR,MUYF,MUYR,BETASF,BETASR,SNR,
     7    KSW,KBF,KBR,
     8    KSC,UCMD,TDMAX,
     9    MANDEC,TAUR,TAUP,WC,VETH,YETH,
     A    ABR,ABSTB,ABSTC,ASWS,ASWC,TSW,SWMAX,SWRMAX,
     B    HOV,UOVO,DOVG,HLV,ULVO,DLVG,HNVMIN,HNVAVE,UNVO,DISTSO,DISTNS,
     C    PSIB,LW,TAUD,TAUOVD,
     D    LAV,HAVMIN,HAVAVE,LF,LR,PBO,PSO,PA,TTHRSH,DTHRSH,TLOOK,
     E    ESKY,ESUN,RO,EO,IO,BSUNO,RB,EB,IB,BSUNB,LSKY,LSUR,
     F    TRANS,KL,VO,HO,PLITE,HRTH,HPER,SIGC,KV1,KV2,ALPHMN,
     G    HEYE,HLITE,HOBJ,TAUBM,TAURS,TAURDM,TAURDS,
     H    LSVF,LSVR,WSV,LOV,WOV,UHTH,VHTH
C
      COMMON
     *    MSCEN,MNITE,MDET,MADJ,MVEH,MSTOR,MPRT,
     *    NU,NX,NVAR,NTRIAL,ISEED,DT,DTPRT,DTSTOR,TMAX,
     *    DEGRAD,MPHFPS,G,TIME,MDEC,COLLF,DTCTF,CHDOV,SHDOV,CPSI,SPSI,
     *    FHX,FHY,FHZ,THX,THY,THZ,BETA,HEAD,VTOT,VX,VY,ATOT,AX,AY,
     1    UH1,VH1,WH1,Z1,FX1,FY1,FN1,BET1,FC1,FS1,
```

FIGURE B-11. <u>SUBROUTINE DATAIO</u> PROGRAM LISTING

```
     2     UH2,VH2,WH2,Z2,FX2,FY2,FN2,BET2,FC2,FS2,
     3     UH3,VH3,WH3,Z3,FX3,FY3,FN3,BET3,FC3,FS3,
     4     UH4,VH4,WH4,Z4,FX4,FY4,FN4,BET4,FC4,FS4
C
      COMMON /TABLE/
     1     NCAT,NGLARE,NMERG,NPTD,NPTXE,NPTYE,NPTXF,NPTYF,NPTXG,NPTYG,
     2     PCAT(10),THFM(10),THFS(10),PSFM(10),PSFS(10),TAUFM(10),
     3     TAUFS(10),EG(10),THG(10),PSG(10),PMERG(36),YID(20),FYD(20),
     4     XIE(20),YIE(10),FXYE(20,10),XIF(10),YIF(10),FXYF(10,10),
     5     XIG(10),YIG(30),FXYG(10,30)
C
      NAMELIST /PARAML/
     1     UHO,VHO,WHO,XO,YO,ZO,
     2     WXO,WYO,WZO,PHIO,THEO,PSIO,
     3     WEIGHT,IXX,IYY,IZZ,
     4     DF,DR,TF,TR,ZF,ZR,HF,HR,
     5     KF,KR,CF,CR,
     6     MUXF,MUXR,MUYF,MUYR,BETASF,BETASR,SNR,
     7     KSW,KBF,KBR,
     8     KSC,UCMD,TDMAX,
     9     MANDEC,TAUR,TAUP,WC,VETH,YETH,
     A     ABR,ABSTB,ABSTC,ASWS,ASWC,TSW,SWMAX,SWRMAX,
     B     HOV,UOVO,DOVG,HLV,ULVO,DLVG,HNVMIN,HNVAVE,UNVO,DISTSO,DISTNS,
     C     PSIB,LW,TAUD,TAUOVD,
     D     LAV,HAVMIN,HAVAVE,LF,LR,PBO,PSO,PA,TTHRSH,DTHRSH,TLOOK,
     E     ESKY,ESUN,RO,EO,IO,BSUNO,RB,EB,IB,BSUNB,LSKY,LSUR,
     F     TRANS,KL,VO,HO,PLITE,HRTH,HPER,SIGC,KV1,KV2,ALPHMN,
     G     HEYE,HLITE,HOBJ,TAUBM,TAUBS,TAURDM,TAURDS,
     H     LSVF,LSVR,WSV,LOV,WOV,UHTH,VHTH
C
      REAL*4 YES / 1HY /, NOH / 1HN /
      INTEGER NUMBER(12) / 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 /
      REAL*8 DASH /6H------/, STAR /6H******/
      REAL*8 DNLAB(2) / 5H DAY , 5HNIGHT /
      REAL*8 VMLAB(7) / 4HNONE, 5H1 DOF, 5H2 DOF, 5H3 DOF, 3*5H6 DOF /
      COMPLEX*16 DMLAB(2) / 15HPURE TIME DELAY, 16HEVENT DET. MODEL /
      COMPLEX*16 ADJLAB(2) / 4HNONE, 14HNORMAL TRAFFIC /
      COMPLEX*16 STOLAB(3) /10HNO STORAGE,10HSTORE DATA,11HRECALL DATA/
      COMPLEX*16 PRTLAB(3) / 15HOVERALL SUMMARY, 16HIND. RUN SUMMARY,
     *     15HIND. TIME HIST. /
C
      EQUIVALENCE (UHO,PAR(1))
C
 1179 FORMAT(//1X,26HPROGRAM CONTROL PARAMETERS)
 1180 FORMAT(/3X, 9HSCENARIO ,I2,3H : ,10A8)
 1181 FORMAT(/3X,17HDAY/NIGHT MODE : ,I1,2H (,A5,1H))
 1182 FORMAT(/3X,23HEVENT DETECTION MODE : ,I1,2H (,2A8,1H))
 1183 FORMAT(/3X,29HADJACENT LANE TRAFFIC MODE : ,I1,2H (,2A8,1H))
 1184 FORMAT(/3X,22HVEHICLE MODEL ORDER : ,I1,2H (,A5,1H))
 1185 FORMAT(/3X,31HTRAJECTORY DATA STORAGE MODE : ,I1,2H (,2A8,1H))
 1186 FORMAT(/3X,29HDATA PRINTOUT CONTROL MODE : ,I1,2H (,2A8,1H),
     *     5X,5H(NU =,I3,6H, NX =,I3,8H, NVAR =,I3,1H))
 1187 FORMAT(/3X,31HNUMBER OF MONTE CARLO TRIALS : ,I5)
 1188 FORMAT(/3X,31HRANDOM NUMBER GENERATOR SEED : ,I3)
 1189 FORMAT(/3X,36HTIME PARAMETERS : INTEGRATION STEP =,F6.3,
     *     14H, PRINT STEP =,F6.3,16H, STORAGE STEP =,F6.3,
     *     20H, MAXIMUM RUN TIME =,F7.3)
 1190 FORMAT(//1X,49HDO YOU WISH TO MODIFY PROGRAM CONTROL PARAMETERS?)
 1210 FORMAT(//
     * 1X,59HTYPE IN APPROPRIATE RESPONSE TO EACH OF THE FOLLOWING QUEST
     * 5HIONS./
```

FIGURE B-11. (continued)

```
     * 1X,53HALL RESPONSES SHOULD BE NUMERIC WITH THE EXCEPTIONS :/
     * 11X,27H / = NO CHANGE FROM NOMINAL /
     * 11X,26H-1 = NEED MORE INFORMATION /
     * 11X,57H-2 = NO FURTHER PROGRAM CONTROL PARAMETER CHANGES DESIRED)
 1211 FORMAT(3X,16HSCENARIO NUMBER?)
 1212 FORMAT(3X,15HDAY/NIGHT MODE?)
 1213 FORMAT(3X,21HEVENT DETECTION MODE?)
 1214 FORMAT(3X,27HADJACENT LANE TRAFFIC MODE?)
 1215 FORMAT(3X,20HVEHICLE MODEL ORDER?)
 1216 FORMAT(3X,37HVEHICLE TRAJECTORY DATA STORAGE MODE?)
 1217 FORMAT(3X,27HDATA PRINTOUT CONTROL MODE?)
 1218 FORMAT(3X,48HNUMBER OF CONTROL INPUTS FOR TIME HISTORY (0-2)?)
 1219 FORMAT(3X,50HNUMBER OF STATE VARIABLES FOR TIME HISTORY (0-18)?)
 1220 FORMAT(3X,50HNUMBER OF INTERMEDIATE VARIABLES FOR TIME HISTORY ,
     1       7H(0-54)?)
 1221 FORMAT(3X,35HNUMBER OF MONTE CARLO TRIALS (>=0)?)
 1222 FORMAT(3X,36HRANDOM NUMBER GENERATOR SEED (0-13)?)
 1223 FORMAT(3X,52HINTEGRATION TIME STEP FOR DRIVER/VEHICLE SIMULATION ,
     1       7H(>0.0)?)
 1224 FORMAT(3X,36HTIME STEP FOR TIME HISTORY PRINTOUT ,
     1       31H(MULTIPLE OF INTEGRATION STEP)?)
 1225 FORMAT(3X,48HSAMPLE TIME STEP FOR VEHICLE TRAJECTORY STORAGE ,
     1       31H(MULTIPLE OF INTEGRATION STEP)?)
 1226 FORMAT(3X,48HMAXIMUM RUN TIME FOR EACH MONTE CARLO ITERATION?)
 1230 FORMAT(5X,23HCORRECT RESPONSES ARE : /(7X,I2,3H = ,A8))
 1231 FORMAT(5X,23HCORRECT RESPONSES ARE : /(7X,I2,3H = ,2A8))
 1232 FORMAT(5X,23HCORRECT RESPONSES ARE : /(7X,I2,3H = ,10A8))
 1250 FORMAT(//1X,46HDO YOU WISH TO INCREASE NUMBER OF MONTE CARLO ,
     * 7HTRIALS?)
 1255 FORMAT(/1X,50HTYPE IN TOTAL NUMBER OF MONTE CARLO TRIALS DESIRED)
 1000 FORMAT(10A8)
 1005 FORMAT(/(3X,10A8))
 1006 FORMAT(/3X,9A8/)
 1007 FORMAT(5X,A8,G12.4,4X,9A8)
 1198 FORMAT(//1X,35HNOMINAL SIMULATION PARAMETER VALUES)
 1201 FORMAT(//1X,29HVISUAL FIXATION CATEGORY DATA//
     *       7X3HCAT,9X4HPCAT,6X7HTHETAFM,5X7HTHETAFS,7X5HPSIFM,
     *       7X5HPSIFS,7X5HTAUFM,7X5HTAUFS/)
 1202 FORMAT(//1X,17HGLARE SOURCE DATA//
     *       8X3HNO.,9X2HEG,8X6HTHETAG,8X4HPSIG/)
 1203 FORMAT(//1X,47HLINE-OF-SIGHT PROBABILITIES TO INTERSECTING OR
     *       22HMERGING VEHICLE, PMERG/)
 1204 FORMAT(//1X,50HLUMINOUS INTENSITY OF SUBJECT VEHICLE HEADLIGHTS,
     *       3HISV//4X6HGAMMAV,8X3HISV/)
 1205 FORMAT(//1X,51HLUMINOUS INTENSITY OF ONCOMING VEHICLE HEADLIGHTS,
     *       3HINV//40X6HGAMMAH)
 1206 FORMAT(3X6HGAMMAV)
 1207 FORMAT(//1X,43HFOVEAL THRESHOLD CONTRAST DATA, LOG10(CFOV)//
     *      40X11HLOG10(AREA))
 1208 FORMAT(1X12HLOG10(LA+LV))
 1209 FORMAT(//1X,47HPERIPHERAL THRESHOLD CONTRAST DATA, LOG10(CPER)//
     *      40X11HLOG10(AREA))
 1195 FORMAT(3X,5HALPHA)
 1199 FORMAT(36H ***** PARAMETER LIST TOO LONG *****)
 1241 FORMAT(34H ***** INTEGRATION TIME STEP  DT =,F10.6,
     *       37H  IS LESS THAN OR EQUAL TO ZERO *****)
 1242 FORMAT(47H ***** TIME-HISTORY PRINTOUT TIME STEP  DTPRT =,F10.6,
     *       25H  IS LESS THAN ZERO *****)
 1243 FORMAT(39H ***** DATA STORAGE TIME STEP  DTSTOR =,F10.6,
     *       25H  IS LESS THAN ZERO *****)
 1244 FORMAT(31H ***** MAXIMUM RUN TIME  TMAX =,F10.6,
```

FIGURE B-11. (continued)

```
     *       25H  IS LESS  THAN ZERO *****)
 1260 FORMAT(55H ***** TOTAL NUMBER INDEPENDENT VARIABLES GREATER THAN
     *       8H50 *****)
 1270 FORMAT(18H ***** PARAMETER  ,A6,24H  CANNOT APPEAR IN THIS
     *       57HINDEPENDENT VARIABLE GROUP FOR STORED VEHICLE TRAJECTORY
     *       11HMODES *****)
 1280 FORMAT(18H ***** PARAMETER  ,A6,30H  CANNOT BE A RANDOM VARIABLE
     *       49HSINCE IT IS ALREADY AN INDEPENDENT VARIABLE *****)
 1290 FORMAT(18H ***** PARAMETER  ,A6,30H  CANNOT BE A RANDOM VARIABLE
     *       41HFOR STORED VEHICLE TRAJECTORY MODES *****)
 1150 FORMAT(A1)
 1151 FORMAT(I10,2X,7F12.4)
 1156 FORMAT(18F6.3)
 1165 FORMAT(11X,12F9.2)
 1170 FORMAT(F6.0,2X,12F6.0/(8X,12F6.0))
 1175 FORMAT(F9.2,2X,12F9.2/(11X,12F9.2))
 1045 FORMAT(//1X,23HINDEPENDENT VARIABLES (,I2,8H GROUPS,,
     *       I2,19H LEVELS OF STORAGE))
 1115 FORMAT(/3X,5HGROUP,I2,2H (,I2,12H VARIABLES, ,I2,8H LEVELS),/)
 1055 FORMAT(5X,A8,1X,10F10.5)
 1046 FORMAT(//1X,16HRANDOM VARIABLES)
 1125 FORMAT(1X,A8,I5,1X,2F10.5)
 1135 FORMAT(10X,11F10.5)
C
      NPAR = 118
      GO TO (100, 200), MODE
C
C READ LABELS FOR CONTROLS, STATES, OUTPUTS, SCENARIOS FROM DISK FILE 1
C
  100 READ (1,1000) LABU
      READ (1,1000) LABX
      READ (1,1000) LABY
      READ (1,1000) SCLAB
C
C READ NOMINAL PROGRAM CONTROL PARAMETERS FROM DISK FILE 2
C
      READ (2,1150) IOFLAG
      READ (2,  * ) MSCEN, MNITE, MDET, MADJ, MVEH, MSTOR
      READ (2,  * ) MPRT, NU, NX, NVAR
      READ (2,  * ) NTRIAL, ISEED
      READ (2,  * ) DT, DTPRT, DTSTOR, TMAX
C
C VERIFY THAT MODE FLAGS AND TIME CONTROL PARAMETERS ARE WITHIN BOUNDS
C
      ISTOP = 0
      CALL IERRCK(MSCEN,5HMSCEN,0,11,ISTOP)
      CALL IERRCK(MNITE,5HMNITE,0, 1,ISTOP)
      CALL IERRCK(MDET ,5HMDET ,0, 1,ISTOP)
      CALL IERRCK(MADJ ,5HMADJ ,0, 1,ISTOP)
      CALL IERRCK(MVEH ,5HMVEH ,0, 6,ISTOP)
      CALL IERRCK(MSTOR,5HMSTOR,0, 2,ISTOP)
      CALL IERRCK(MPRT ,5HMPRT ,0, 2,ISTOP)
      CALL IERRCK(NU   ,5HNU   ,0, 2,ISTOP)
      CALL IERRCK(NX   ,5HNX   ,0,18,ISTOP)
      CALL IERRCK(NVAR ,5HNVAR ,0,54,ISTOP)
      CALL IERRCK(NTRIAL,6HNTRIAL,0,1000000,ISTOP)
      CALL IERRCK(ISEED,5HISEED,0,13,ISTOP)
      CALL RERRCK(DT    ,6HDT    ,0.,1.0E6,ISTOP)
      CALL RERRCK(DTPRT ,6HDTPRT ,0.,1.0E6,ISTOP)
      CALL RERRCK(DTSTOR,6HDTSTOR,0.,1.0E6,ISTOP)
      CALL RERRCK(TMAX  ,6HTMAX  ,0.,1.0E6,ISTOP)
```

FIGURE B-11. (continued)

```
C
C PRINT PROGRAM CONTROL PARAMETERS
C
  550 WRITE(6,1179)
      WRITE(6,1180) MSCEN, (SCLAB(I,MSCEN+1),I=1,10)
      WRITE(6,1181) MNITE, DNLAB(MNITE+1)
      WRITE(6,1182) MDET, DMLAB(MDET+1)
      WRITE(6,1183) MADJ, ADJLAB(MADJ+1)
      WRITE(6,1184) MVEH, VMLAB(MVEH+1)
      WRITE(6,1185) MSTOR, STOLAB(MSTOR+1)
      WRITE(6,1186) MPRT, PRTLAB(MPRT+1), NU, NX, NVAR
      WRITE(6,1187) NTRIAL
      WRITE(6,1188) ISEED
      WRITE(6,1189) DT, DTPRT, DTSTOR, TMAX
C
      WRITE(7,1179)
      WRITE(7,1180) MSCEN, (SCLAB(I,MSCEN+1),I=1,10)
      WRITE(7,1181) MNITE, DNLAB(MNITE+1)
      WRITE(7,1182) MDET, DMLAB(MDET+1)
      WRITE(7,1183) MADJ, ADJLAB(MADJ+1)
      WRITE(7,1184) MVEH, VMLAB(MVEH+1)
      WRITE(7,1185) MSTOR, STOLAB(MSTOR+1)
      WRITE(7,1186) MPRT, PRTLAB(MPRT+1), NU, NX, NVAR
      WRITE(7,1187) NTRIAL
      WRITE(7,1188) ISEED
      WRITE(7,1189) DT, DTPRT, DTSTOR, TMAX
      IF(IOFLAG .EQ. NOH) GO TO 560
C
C TYPE IN PROGRAM CONTROL PARAMETER MODIFICATIONS: VERIFY THAT DATA IS
C WITHIN BOUNDS
C
  500 WRITE(6,1190)
      WRITE(7,1190)
      READ (5,1150) CHAR
      WRITE(7,1150) CHAR
      IF(CHAR .EQ. NOH) GO TO 560
      IF(CHAR .NE. YES) GO TO 500
      WRITE(6,1210)
C
C     SCENARIO NUMBER
  511 WRITE(6,1211)
      NUM = MSCEN
      READ (5,  * ) NUM
      IF(NUM .EQ. -1) GO TO 611
      IF(NUM .EQ. -2) GO TO 550
      IF(NUM .LT. 0 .OR. NUM .GT. 11) GO TO 611
      MSCEN = NUM
      GO TO 512
  611 WRITE(6,1232) (NUMBER(I), (SCLAB(J,I),J=1,10), I=1,12)
      GO TO 511
C
C     DAY/NIGHT MODE
  512 WRITE(6,1212)
      NUM = MNITE
      READ (5,  * ) NUM
      IF(NUM .EQ. -1) GO TO 612
      IF(NUM .EQ. -2) GO TO 550
      IF(NUM .LT. 0 .OR. NUM .GT. 1) GO TO 612
      MNITE = NUM
      GO TO 513
  612 WRITE(6,1230) (NUMBER(I), DNLAB(I), I=1,2)
```

FIGURE B-11. (continued)

```
      GO TO 512
C
C     EVENT DETECTION MODE
  513 WRITE(6,1213)
      NUM = MDET
      READ (5,  * ) NUM
      IF(NUM .EQ. -1) GO TO 613
      IF(NUM .EQ. -2) GO TO 550
      IF(NUM .LT. 0 .OR. NUM .GT. 1) GO TO 613
      MDET = NUM
      GO TO 514
  613 WRITE(6,1231) (NUMBER(I), DMLAB(I), I=1,2)
      GO TO 513
C
C     ADJACENT LANE TRAFFIC MODE
  514 WRITE(6,1214)
      NUM = MADJ
      READ (5,  * ) NUM
      IF(NUM .EQ. -1) GO TO 614
      IF(NUM .EQ. -2) GO TO 550
      IF(NUM .LT. 0 .OR. NUM .GT. 1) GO TO 614
      MADJ = NUM
      GO TO 515
  614 WRITE(6,1231) (NUMBER(I), ADJLAB(I), I=1,2)
      GO TO 514
C
C     VEHICLE MODEL ORDER (SUBJECT VEHICLE)
  515 WRITE(6,1215)
      NUM = MVEH
      READ (5,  * ) NUM
      IF(NUM .EQ. -1) GO TO 615
      IF(NUM .EQ. -2) GO TO 550
      IF(NUM .LT. 0 .OR. NUM .GT. 6) GO TO 615
      MVEH = NUM
      GO TO 516
  615 WRITE(6,1230) (NUMBER(I), VMLAB(I), I=1,7)
      GO TO 515
C
C     SUBJECT VEHICLE TRAJECTORY DATA STORAGE MODE
  516 WRITE(6,1216)
      NUM = MSTOR
      READ (5,  * ) NUM
      IF(NUM .EQ. -1) GO TO 616
      IF(NUM .EQ. -2) GO TO 550
      IF(NUM .LT. 0 .OR. NUM .GT. 2) GO TO 616
      MSTOR = NUM
      GO TO 517
  616 WRITE(6,1231) (NUMBER(I), STOLAB(I), I=1,3)
      GO TO 516
C
C     DATA PRINTOUT CONTROL MODE
  517 WRITE(6,1217)
      NUM = MPRT
      READ (5,  * ) NUM
      IF(NUM .EQ. -1) GO TO 617
      IF(NUM .EQ. -2) GO TO 550
      IF(NUM .LT. 0 .OR. NUM .GT. 2) GO TO 617
      MPRT = NUM
      IF(MPRT .LT. 2) GO TO 521
      GO TO 518
  617 WRITE(6,1231) (NUMBER(I), PRTLAB(I), I=1,3)
```

FIGURE B-11. (continued)

```
      GO TO 517
C
C     NUMBER OF VEHICLE CONTROL INPUTS FOR TIME HISTORY PRINTOUT (0-2)
  518 WRITE(6,1218)
      NUM = NU
      READ (5,  * ) NUM
      IF(NUM .EQ. -2) GO TO 550
      IF(NUM .LT. 0 .OR. NUM .GT. 2) GO TO 518
      NU = NUM
C
C     NUMBER OF VEHICLE STATE VARIABLES FOR TIME HISTORY PRINTOUT (0-18)
  519 WRITE(6,1219)
      NUM = NX
      READ (5,  * ) NUM
      IF(NUM .EQ. -2) GO TO 550
      IF(NUM .LT. 0 .OR. NUM .GT. 18) GO TO 519
      NX = NUM
C
C     NUMBER OF VEHICLE VARIABLES FOR TIME HISTORY PRINTOUT (0-54)
  520 WRITE(6,1220)
      NUM = NVAR
      READ (5,  * ) NUM
      IF(NUM .EQ. -2) GO TO 550
      IF(NUM .LT. 0 .OR. NUM .GT. 54) GO TO 520
      NVAR = NUM
C
C     NUMBER OF MONTE CARLO TRAILS (>=0)
  521 WRITE(6,1221)
      NUM = NTRIAL
      READ (5,  * ) NUM
      IF(NUM .EQ. -2) GO TO 550
      IF(NUM .LT. 0) GO TO 521
      NTRIAL = NUM
C
C     RANDOM NUMBER GENERATOR SEED INDEX (0-13)
  522 WRITE(6,1222)
      NUM = ISEED
      READ (5,  * ) NUM
      IF(NUM .EQ. -2) GO TO 550
      IF(NUM .LT. 1 .OR. NUM .GT. 13) GO TO 522
      ISEED = NUM
C
C     INTEGRATION TIME STEP FOR DRIVER/VEHICLE SIMULATION
  523 WRITE(6,1223)
      DUM = DT
      READ (5,  * ) DUM
      IF(DUM .EQ. -2.0) GO TO 550
      IF(DUM .LE. 0.0) GO TO 623
      DT = DUM
      GO TO 524
  623 WRITE(6,1241) DUM
      GO TO 523
C
C     TIME STEP FOR TIME HISTORY PRINTOUT
  524 WRITE(6,1224)
      DUM = DTPRT
      READ (5,  * ) DUM
      IF(DUM .EQ. -2.0) GO TO 550
      IF(DUM .LT. 0.0) GO TO 624
      DTPRT = DUM
```

FIGURE B-11. (continued)

```
      GO TO 525
  624 WRITE(6,1242) DUM
      GO TO 524
C
C     SAMPLE TIME STEP FOR VEHICLE TRAJECTORY STORAGE (MSTOR = 1 OR 2)
  525 WRITE(6,1225)
      DUM = DTSTOR
      READ (5,  * ) DUM
      IF(DUM .EQ. -2.0) GO TO 550
      IF(DUM .LT. 0.0) GO TO 625
      DTSTOR = DUM
      GO TO 526
  625 WRITE(6,1243) DUM
      GO TO 525
C
C     MAXIMUM RUN TIME FOR EACH MONTE CARLO ITERATION
  526 WRITE(6,1226)
      DUM = TMAX
      READ (5,  * ) DUM
      IF(DUM .EQ. -2.0) GO TO 550
      IF(DUM .LT. 0.0) GO TO 626
      TMAX = DUM
      GO TO 550
  626 WRITE(6,1244) DUM
      GO TO 526
C
C
C READ NOMINAL NAMELIST PARAMETER VALUES FROM DISK FILE 2
C
  560 READ (2,PARAML)
C
C READ SIMULATION PARAMETER LABELS, VALUES, DESCRIPTIONS FROM FILE 1;
C PRINT RESULTS ON DISK FILE 9
C
      IP = 0
      WRITE(9,1198)
   61 READ (1,1000) BUFF
      IF(BUFF(1) .EQ. DASH) GO TO 63
      IF(BUFF(1) .EQ. STAR) GO TO 62
      IP = IP + 1
      IF(IP .GT. NPAR) GO TO 64
      LABP(IP) = BUFF(1)
      WRITE(9,1007) LABP(IP), PAR(IP), (BUFF(I),I=2,10)
      GO TO 61
   63 WRITE(9,1006) (BUFF(I),I=2,10)
      GO TO 61
   64 WRITE(6,1199)
      ISTOP = 1
   62 CONTINUE
C
C VERIFY THAT SELECTED SIMULATION PARAMETERS ARE WITHIN BOUNDS
C
      CALL RERRCK(SNR    ,6HSNR    ,0.,1.,ISTOP)
      CALL RERRCK(MANDEC,6HMANDEC,0.,3.,ISTOP)
      CALL RERRCK(ABSTB  ,6HABSTB  ,0.,1.,ISTOP)
      CALL RERRCK(ABSTC  ,6HABSTC  ,0.,1.,ISTOP)
      CALL RERRCK(PBO    ,6HPBO    ,0.,1.,ISTOP)
      CALL RERRCK(PSO    ,6HPSO    ,0.,1.,ISTOP)
      CALL RERRCK(PA     ,6HPA     ,0.,1.,ISTOP)
      CALL RERRCK(RO     ,6HRO     ,0.,1.,ISTOP)
```

FIGURE B-11. (continued)

```
      CALL RERRCK(RB     ,6HRB     ,0.,1.,ISTOP)
      CALL RERRCK(TRANS  ,6HTRANS  ,0.,1.,ISTOP)
      CALL RERRCK(PLITE  ,6HPLITE  ,0.,1.,ISTOP)
      CALL RERRCK(HRTH   ,6HHRTH   ,0.,1.,ISTOP)
C
C MODIFY SELECTED PARAMETERS TO AVOID POSSIBLE DIVISION BY ZERO
C
      WEIGHT = AMAX1(WEIGHT,0.001)
      IXX = AMAX1(IXX,0.001)
      IYY = AMAX1(IYY,0.001)
      IZZ = AMAX1(IZZ,0.001)
      DF = AMAX1(DF,0.001)
      DR = AMAX1(DR,0.001)
      TF = AMAX1(TF,0.001)
      TR = AMAX1(TR,0.001)
      HF = AMAX1(HF,0.001)
      HR = AMAX1(HR,0.001)
      KF = AMAX1(KF,0.001)
      KR = AMAX1(KR,0.001)
      MUXF = AMAX1(MUXF,0.001)
      MUXR = AMAX1(MUXR,0.001)
      MUYF = AMAX1(MUYF,0.001)
      MUYR = AMAX1(MUYR,0.001)
      BETASF = AMAX1(BETASF,0.001)
      BETASR = AMAX1(BETASR,0.001)
      SNR = AMAX1(SNR,0.001)
      KSW = AMAX1(KSW,0.001)
      KBF = AMAX1(KBF,0.001)
      KBR = AMAX1(KBR,0.001)
      TAUP = AMAX1(TAUP,0.001)
      TSW = AMAX1(TSW,0.001)
C
C READ TABLE DATA FOR CRITICAL EVENT DETECTION MODEL FROM DISK FILE 2;
C PRINT RESULTS ON DISK FILE 9
C
C     VISUAL FIXATION CATEGORY DATA
      READ (2,  * ) NCAT
      CALL IERRCK(NCAT,4HNCAT,0,10,ISTOP)
      IF(NCAT .EQ. 0) GO TO 415
      WRITE(9,1201)
      DO 410 I = 1, NCAT
      READ (2,  * ) PCAT(I),THFM(I),THFS(I),PSFM(I),PSFS(I),
     1     TAUFM(I),TAUFS(I)
  410 WRITE(9,1151) I, PCAT(I),THFM(I),THFS(I),PSFM(I),PSFS(I),
     1     TAUFM(I),TAUFS(I)
C
C     GLARE SOURCE DATA
  415 READ (2,  * ) NGLARE
      CALL IERRCK(NGLARE,6HNGLARE,0,10,ISTOP)
      IF(NGLARE .EQ. 0) GO TO 425
      WRITE(9,1202)
      DO 420 I = 1,NGLARE
      READ (2,  * ) EG(I), THG(I), PSG(I)
  420 WRITE(9,1151) I, EG(I), THG(I), PSG(I)
C
C     LOS PROBABILITY TO INTERSECTING OR MERGING VEHICLE
  425 READ (2,  * ) NMERG
      CALL IERRCK(NMERG,5HNMERG,0,36,ISTOP)
      IF(NMERG .EQ. 0) GO TO 435
      WRITE(9,1203)
```

FIGURE B-11. (continued)

```
      READ (2,  * ) (PMERG(I),I=1,NMERG)
      WRITE(9,1156) (PMERG(I),I=1,NMERG)
C
C     LUMINOUS INTENSITY OF SUBJECT VEHICLE HEADLIGHTS
  435 READ (2,  * ) NPTD
      CALL IERRCK(NPTD,4HNPTD,0,20,ISTOP)
      IF(NPTD .EQ. 0) GO TO 445
      WRITE(9,1204)
      DO 440 J = 1, NPTD
      JP = NPTD - J + 1
      READ (2,  * ) YID(JP),FYD(JP)
  440 WRITE(9,1175) YID(JP),FYD(JP)
C
C     LUMINOUS INTENSITY OF ONCOMING VEHICLE HEADLIGHTS
  445 READ (2,  * ) NPTXE,NPTYE
      CALL IERRCK(NPTXE,5HNPTXE,0,20,ISTOP)
      CALL IERRCK(NPTYE,5HNPTYE,0,10,ISTOP)
      IF(NPTXE .EQ. 0 .OR. NPTYE .EQ. 0) GO TO 455
      WRITE(9,1205)
      READ (2,  * ) (XIE(I),I=1,NPTXE)
      WRITE(9,1165) (XIE(I),I=1,NPTXE)
      WRITE(9,1206)
      DO 450 J = 1, NPTYE
      JP = NPTYE - J + 1
      READ (2,  * ) YIE(JP),(FXYE(I,JP),I=1,NPTXE)
  450 WRITE(9,1175) YIE(JP),(FXYE(I,JP),I=1,NPTXE)
C
C     FOVEAL THRESHOLD CONTRAST DATA
  455 READ (2,  * ) NPTXF,NPTYF
      CALL IERRCK(NPTXF,5HNPTXF,0,10,ISTOP)
      CALL IERRCK(NPTYF,5HNPTYF,0,10,ISTOP)
      IF(NPTXF .EQ. 0 .OR. NPTYF .EQ. 0) GO TO 465
      WRITE(9,1207)
      READ (2,  * ) (XIF(I),I=1,NPTXF)
      WRITE(9,1165) (XIF(I),I=1,NPTXF)
      WRITE(9,1208)
      DO 460 J = 1, NPTYF
      READ (2,  * ) YIF(J),(FXYF(I,J),I=1,NPTXF)
  460 WRITE(9,1175) YIF(J),(FXYF(I,J),I=1,NPTXF)
C
C     PERIPHERAL THRESHOLD CONTRAST DATA
  465 READ (2,  * ) NPTXG,NPTYG
      CALL IERRCK(NPTXG,5HNPTXG,0,10,ISTOP)
      CALL IERRCK(NPTYG,5HNPTYG,0,30,ISTOP)
      IF(NPTXG .EQ. 0 .OR. NPTYG .EQ. 0) GO TO 475
      WRITE(9,1209)
      READ (2,  * ) (XIG(I),I=1,NPTXG)
      WRITE(9,1165) (XIG(I),I=1,NPTXG)
      WRITE(9,1195)
      DO 470 J = 1, NPTYG
      READ (2,  * ) YIG(J),(FXYG(I,J),I=1,NPTXG)
  470 WRITE(9,1175) YIG(J),(FXYG(I,J),I=1,NPTXG)
  475 CONTINUE
C
C READ/PRINT INDEPENDENT VARIABLE DATA (NIVG >= 0)
C
      IP = 0
      IMIN = 0
      IMAX = 0
      ITEMP = 0
      DO 7 I = 1, 3
      NO(I) = 1
      INDEX(I) = 0
      DO 7 J = 1, 10
    7 PLIST(I,J) = 0
      CALL FIND(6HUHO    ,LABP,NPAR,IMIN,ISTOP)
```

FIGURE B-11. (continued)

```
      CALL FIND(6HSWRMAX,LABP,NPAR,IMAX,ISTOP)
C
      READ (2,  * ) NIVG, NSTOR
      IF(NIVG .EQ. 0) GO TO 6
      WRITE(6,1045) NIVG, NSTOR
      WRITE(7,1045) NIVG, NSTOR
      CALL IERRCK(NIVG ,5HNIVG ,0, 3,ISTOP)
      CALL IERRCK(NSTOR,5HNSTOR,0, 3,ISTOP)
C
      DO 5 I = 1, NIVG
      READ (2,  * ) NIV(I), NO(I)
      WRITE(6,1115) I, NIV(I), NO(I)
      WRITE(7,1115) I, NIV(I), NO(I)
      NIVI = NIV(I)
      NOI = NO(I)
      CALL IERRCK(NIVI,6HNIV(I),1,50,ISTOP)
      CALL IERRCK(NOI ,6HNO(I) ,1,10,ISTOP)
      IF(MSTOR .EQ. 1 .AND. I .GT. NSTOR) NO(I) = 1
C
      DO 5 K = 1, NIVI
      IP = IP + 1
      IF(IP .GT. 50) GO TO 575
      READ (2,  * ) LAB, (PLIST(IP,J),J=1,NOI)
      WRITE(6,1055) LAB, (PLIST(IP,J),J=1,NOI)
      WRITE(7,1055) LAB, (PLIST(IP,J),J=1,NOI)
      CALL FIND(LAB,LABP,NPAR,ITEMP,ISTOP)
      IF(NO(I) .NE. 1) GO TO 5
      IF(ITEMP .LT. IMIN .OR. ITEMP .GT. IMAX) GO TO 5
      ISTOP = 1
      WRITE(6,1270) LAB
      WRITE(7,1270) LAB
    5 INDEX(IP) = ITEMP
      GO TO 6
  575 ISTOP = 1
      IP = MINO(IP,50)
      WRITE(6,1260)
      WRITE(7,1260)
    6 CONTINUE
C
C READ/PRINT RANDOM VARIABLE DATA (NRV >= 0)
C
      READ (2,  * ) NRV
      IF(NRV .EQ. 0) GO TO 9
      CALL IERRCK(NRV,3HNRV,0,50,ISTOP)
      ITEMP = 0
      WRITE(6,1046)
      WRITE(7,1046)
      DO 8 I = 1, NRV
      READ (2,  * ) LAB, IRVT(I), RVMIN(I), RVMAX(I)
      WRITE(6,1125) LAB, IRVT(I), RVMIN(I), RVMAX(I)
      WRITE(7,1125) LAB, IRVT(I), RVMIN(I), RVMAX(I)
      NUM = IRVT(I)
      CALL IERRCK(NUM,7HIRVT(I),1,5,ISTOP)
      IF(IRVT(I) .NE. 5) GO TO 10
      READ (2,  * ) NPT(I)
      NPTI = NPT(I)
      CALL IERRCK(NPTI,6HNPT(I),1,11,ISTOP)
      READ (2,  * ) (XS(J,I),J=1,NPTI)
      READ (2,  * ) (PS(J,I),J=1,NPTI)
      WRITE(6,1135) (XS(J,I),J=1,NPTI)
      WRITE(6,1135) (PS(J,I),J=1,NPTI)
```

FIGURE B-11. (continued)

```
      WRITE(7,1135) (XS(J,I),J=1,NPTI)
      WRITE(7,1135) (PS(J,I),J=1,NPTI)
   10 CALL FIND(LAB,LABP,NPAR,ITEMP,ISTOP)
      IF(IP .EQ. 0) GO TO 13
      DO 11 K = 1, IP
   11 IF(ITEMP .EQ. INDEX(K)) GO TO 12
      GO TO 13
   12 ISTOP = 1
      WRITE(6,1280) LAB
      WRITE(7,1280) LAB
   13 IF(MSTOR .EQ. 0) GO TO 8
      IF(ITEMP .LT. IMIN .OR. ITEMP .GT. IMAX) GO TO 8
      ISTOP = 1
      WRITE(6,1290) LAB
      WRITE(7,1290) LAB
    8 IRV(I) = ITEMP
    9 CONTINUE
      IF(ISTOP .EQ. 1) STOP 11
      RETURN
C
C TYPE IN NUMBER OF MONTE CARLO TRIALS DESIRED FOR RUN CONTINUATION
C
  200 IF(IOFLAG .EQ. NOH) RETURN
  210 WRITE(6,1250)
      WRITE(7,1250)
      READ (5,1150) CHAR
      WRITE(7,1150) CHAR
      IF(CHAR .EQ. NOH) RETURN
      IF(CHAR .NE. YES) GO TO 210
      WRITE(6,1255)
      WRITE(7,1255)
      NUM = NTRIAL
      READ (5,  * ) NUM
      WRITE(7,  * ) NUM
      IF(NUM .LE. NTRIAL) GO TO 210
      NTRIAL = NUM
      RETURN
      END
```

FIGURE B-11. (concluded)

```
      FUNCTION RAND(MODE,R1,R2,NPT,P,X)
C
C THIS FUNCTION SUBPROGRAM GENERATES PSEUDO RANDOM NUMBERS FROM:
C     1) UNIFORM    DISTRIBUTION ON INTERVAL (R1,R2)
C     2) NEG. EXP. DISTRIBUTION WITH MIN  = R1 AND MEAN  = R2
C     3) GAUSSIAN  DISTRIBUTION WITH MEAN = R1 AND SIGMA = R2
C     4) GAMMA     DISTRIBUTION WITH MEAN = R1 AND SIGMA = R2
C     5) USER-SPECIFIED DISTRIBUTION WITH CUMULATIVE DIST. P VS. X
C
      DIMENSION P(1), X(1)
C
      DATA LAMBDA, SF, SFPI2 / 1220703125, 2.3283064E-10, 1.46291806E-9/
C
      IF(MODE .GT. 0) GO TO 100
      IX = 5**(13+MODE)
      RAND = 0
      RETURN
C
  100 GO TO (110, 120, 130, 140, 150), MODE
C
  110 IX = LAMBDA*IX
      RAN = SF*IX + 0.5
      RAND = R1 + (R2-R1)*RAN
      RETURN
C
  120 IX = LAMBDA*IX
      RAN = SF*IX + 0.5
      RAND = R1 - (R2-R1)*ALOG(RAN)
      RETURN
C
  130 IX = LAMBDA*IX
      RAN = SF*IX + 0.5
      IX = LAMBDA*IX
      PHASE = SFPI2*IX
      RAND = R1 + R2*SQRT(-2.0*ALOG(RAN))*COS(PHASE)
      RETURN
C
  140 IF(R2 .EQ. 0.0) GO TO 146
      TLAM = R1/R2**2
      IR = R1*TLAM + 0.5
      T = 1.0
      DO 145 I = 1, IR
      IX = LAMBDA*IX
      RAN = SF*IX + 0.5
  145 T = T*RAN
      RAND = -ALOG(T)/TLAM
      RETURN
  146 RAND = R1
      RETURN
C
  150 K = NPT/2 + 1
      IX = LAMBDA*IX
      RAN = SF*IX + 0.5
  151 IF(RAN .LT. P(K)) GO TO 152
      K = K + 1
      IF(K .LE. NPT) GO TO 151
      K = NPT
  152 KM = K - 1
      IF(RAN .GE. P(KM)) GO TO 153
      K = KM
```

FIGURE B-12. <u>FUNCTION RAND</u> PROGRAM LISTING

```
          IF(K .GE. 2) GO TO 152
          K = 2
          KM = K - 1
      153 PO = P(KM)
          PI = P(K)
          XO = X(KM)
          XI = X(K)
          RAND = ((XI - XO)/(PI - PO))*(RAN - PO) + XO
          RETURN
          END
```

FIGURE B-12. (concluded)

```
      SUBROUTINE FIND(LABEL,LIST,N,INDEX,ISTOP)
      REAL*8 LABEL, LIST(1)
 1000 FORMAT(18H ***** PARAMETER  ,A8,30H  NOT FOUND IN PARAMETER LIST ,
     *     5H*****)
C
      DO 100 K = 1, N
      KP = MOD(INDEX+K-1,N) + 1
      IF(LABEL .EQ. LIST(KP)) GO TO 200
  100 CONTINUE
C
      WRITE(6,1000) LABEL
      INDEX = 0
      ISTOP = 1
      RETURN
C
  200 INDEX = KP
      RETURN
      END
```

FIGURE B-13. SUBROUTINE FIND PROGRAM LISTING

```
      SUBROUTINE IERRCK(NUM,LABEL,MIN,MAX,IFLAG)
      REAL*8 LABEL
      IF(NUM .GE. MIN .AND. NUM .LE. MAX) RETURN
      WRITE(6,1000) LABEL, NUM, MIN, MAX
 1000 FORMAT(18H ***** PARAMETER  ,A8,1H=,I6,21H  IS OUTSIDE OF RANGE,
     *     I6,4H  TO,I6,6H *****)
      NUM = MINO(NUM,MAX)
      NUM = MAXO(NUM,MIN)
      IFLAG = 1
      RETURN
      END
```

FIGURE B-14. SUBROUTINE IERRCK PROGRAM LISTING

```
      SUBROUTINE RERRCK(NUM,LABEL,MIN,MAX,IFLAG)
      REAL NUM,MIN,MAX
      REAL*8 LABEL
      IF(NUM .GE. MIN .AND. NUM .LE. MAX) RETURN
      WRITE(6,1000) LABEL, NUM, MIN, MAX
 1000 FORMAT(18H ***** PARAMETER  ,A8,1H=,G12.4,21H  IS OUTSIDE OF RANGE
     *     ,G12.4,4H  TO,G12.4,6H *****)
      NUM = AMIN1(NUM,MAX)
      NUM = AMAX1(NUM,MIN)
      IFLAG = 1
      RETURN
      END
```

FIGURE B-15. SUBROUTINE RERRCK PROGRAM LISTING

```
      FUNCTION FLOOK1(X,XI,IXU,F,NPX)
C **** SUBPROGRAMS NEEDED - INDEX
C THIS FUNCTION INTERPOLATES A SINGLE VARIABLE FUNCTION TABLE
C
      DIMENSION XI(1),F(1)
C
C
      IF(NPX .EQ. 0) GO TO 10
      CALL INDEX(X,XI,NPX,IXL,IXU)
      SX = 0.0
      T1 = XI(IXU) - XI(IXL)
      IF(T1 .NE. 0.0) SX = (X - XI(IXL))/T1
      FLOOK1 = F(IXL) + SX*(F(IXU) - F(IXL))
      RETURN
   10 FLOOK1 = 0
      RETURN
      END
```

FIGURE B-16. <u>FUNCTION FLOOK1</u> PROGRAM LISTING

```
      FUNCTION FLOOK2(X,Y,XI,IXU,YI,IYU,F,NPX,NPY,NPXM)
C **** SUBPROGRAMS NEEDED - INDEX
C THIS FUNCTION INTERPOLATES A BI-VARIABLE FUNCTION TABLE
C
      DIMENSION XI(1),YI(1),F(NPXM,1)
C
C
      IF(NPX .EQ. 0 .OR. NPY .EQ. 0) GO TO 10
      CALL INDEX(X,XI,NPX,IXL,IXU)
      CALL INDEX(Y,YI,NPY,IYL,IYU)
      SX = 0.0
      SY = 0.0
      T1 = XI(IXU) - XI(IXL)
      T2 = YI(IYU) - YI(IYL)
      IF(T1 .NE. 0.0) SX = (X - XI(IXL))/T1
      IF(T2 .NE. 0.0) SY = (Y - YI(IYL))/T2
      T1 = F(IXL,IYL) + SX*(F(IXU,IYL) - F(IXL,IYL))
      T2 = F(IXL,IYU) + SX*(F(IXU,IYU) - F(IXL,IYU))
      FLOOK2 = T1 + SY*(T2 - T1)
      RETURN
   10 FLOOK2 = 0
      RETURN
      END
```

FIGURE B-17. <u>FUNCTION FLOOK2</u> PROGRAM LISTING

```
      SUBROUTINE INDEX(V,VI,N,IVL,IVU)
C **** SUBPROGRAMS NEEDED - (NONE)
C THIS SUBROUTINE FINDS THE LOWER AND UPPER INDICES IVL AND IVU
C FOR THE VECTOR VI SUCH THAT   VI(IVL) < V <= VI(IVU).   IF
C V <= VI(1), BOTH IVL AND IVU ARE RETURNED AS 1. IF V >= VI(N),
C BOTH IVL AND IVU ARE RETURNED AS N. A SIMPLE SEQUENTIAL
C SEARCH IS USED STARTING FROM
C THE LAST UPPER INDEX FOR THE VECTOR IDENTIFIED BY NUMBER IVU.
C THE VALUES IN THE VECTOR V ARE ASSUMED TO BE ARRANGED IN
C ASCENDING ORDER
C
C
      DIMENSION VI(1)
C
C
      IVU = MAXO(IVU,1)
      IVU = MINO(IVU,N)
      IF(V .LT. VI(IVU)) GO TO 40
   10   IF(VI(IVU) .GE. V) GO TO 30
          IF(IVU .EQ. N) GO TO 20
            IVU = IVU + 1
            GO TO 10
   20     IVL = IVU
          GO TO 80
   30   IVL = MAXO(IVU-1,1)
        GO TO 80
   40 IVL = MAXO(IVU-1,1)
   50 IF(VI(IVL) .LT. V) GO TO 70
        IF(IVL .EQ. 1) GO TO 60
          IVL = IVL - 1
          GO TO 50
   60   IVU = IVL
        GO TO 80
   70 IVU = MINO(IVL+1,N)
   80 RETURN
      END
```

FIGURE B-18. SUBROUTINE INDEX PROGRAM LISTING

APPENDIX C

DRIVEM PROGRAM SAMPLE INPUT/OUTPUT

This appendix presents sample input and output for the DRIVEM simulation. Complete input and output are shown for a simple example discussed in Sections 13 and 14 to illustrate the various I/O options in the DRIVEM simulation. The example simulates scenario 5 under nighttime conditions where subject, object, lead, and oncoming vehicles are considered. It is representative of applications of the DRIVEM simulation with the exception that the number of trials (NTRIAL) would normally be much larger and the printout control flag (MPRT) would normally be zero for practical applications. All input/output of interest to the potential user is shown here except for the basic terminal input/output, which appears in Section 14, Figure 14-1. This terminal I/O, however, is essentially identical to that written on file 7 and illustrated in Figure C-4.

LIST OF ILLUSTRATIONS

```
type label data

DELSW    DELB
UH       VH       WH       X        Y        Z        WX       WY       WZ       PHI
THETA    PSI      UOV      XOV      ULV      XLV      UNV      XNV
FHX      FHY      FHZ      THX      THY      THZ      BETA     HEADING  VTOT     VX
VY       ATOT     AX       AY       UH1      VH1      WH1      Z1       FX1      FY1
FN1      BETA1    FC1      FS1      UH2      VH2      WH2      Z2       FX2      FY2
FN2      BETA2    FC2      FS2      UH3      VH3      WH3      Z3       FX3      FY3
FN3      BETA3    FC3      FS3      UH4      VH4      WH4      Z4       FX4      FY4
FN4      BETA4    FC4      FS4
NONE
FOLLOWING, FREEWAY
FOLLOWING, FREEWAY, INTERVENING VEHICLE
FOLLOWING, FREEWAY ENTRANCE RAMP
FOLLOWING, URBAN STREET
FOLLOWING, URBAN STREET, INTERVENING VEHICLE
LATERALLY MOVING VEHICLE, FREEWAY ENTRANCE RAMP
LATERALLY MOVING VEHICLE, INTERSECTION, VEHICLE APPROACH FROM RIGHT
LATERALLY MOVING VEHICLE, INTERSECTION, VEHICLE APPROACH FROM LEFT
OBJECT ON ROADWAY, PEDESTRIAN MOVES FROM CONCEALED POSITION
STATIONARY OBJECT ON ROADWAY
STATIONARY OBJECT ON ROADWAY, ONCOMING VEHICLE
------   INITIAL CONDITIONS (SUBJECT VEHICLE)
UHO      INITIAL LONG. VELOCITY OF CG IN HORIZONTAL BODY AXES, MPH (+ FORWARD)
VHO      INITIAL LAT.  VELOCITY OF CG IN HORIZONTAL BODY AXES, MPH (+ RIGHT)
WHO      INITIAL VERT. VELOCITY OF CG IN HORIZONTAL BODY AXES, MPH (+ DOWN)
XO       INITIAL LONG. POSITION OF CG IN INERTIAL AXES, FT (+ FORWARD)
YO       INITIAL LAT.  POSITION OF CG IN INERTIAL AXES, FT (+ RIGHT)
ZO       INITIAL VERT. POSITION OF CG IN INERTIAL AXES, FT (+ DOWN)
WXO      INITIAL ANGULAR RATE ABOUT X BODY AXIS, DEG/SEC (+ CLOCKWISE)
WYO      INITIAL ANGULAR RATE ABOUT Y BODY AXIS, DEG/SEC (+ CLOCKWISE)
WZO      INITIAL ANGULAR RATE ABOUT Z BODY AXIS, DEG/SEC (+ CLOCKWISE)
PHIO     INITIAL ROLL ATTITUDE, DEG (+CLOCKWISE)
THEO     INITIAL PITCH ATTITUDE, DEG (+CLOCKWISE)
PSIO     INITIAL YAW ATTITUDE, DEG (+CLOCKWISE)
------   VEHICLE MODEL PARAMETERS (SUBJECT VEHICLE)
WEIGHT   VEHICLE WEIGHT, LB
IXX      ROLL  PRINCIPAL MOMENT OF INERTIA ABOUT X BODY AXIS, FT-LB-SEC**2
IYY      PITCH PRINCIPAL MOMENT OF INERTIA ABOUT Y BODY AXIS, FT-LB-SEC**2
IZZ      YAW   PRINCIPAL MOMENT OF INERTIA ABOUT Z BODY AXIS, FT-LB-SEC**2
DF       DISTANCE FROM CG TO SPIN AXES OF FRONT WHEELS, FT
DR       DISTANCE FROM CG TO SPIN AXES OF REAR WHEELS, FT
TF       HALF TREAD WIDTH OF FRONT WHEELS (HALF OF DISTANCE BETWEEN WHEELS), FT
TR       HALF TREAD WIDTH OF REAR  WHEELS (HALF OF DISTANCE BETWEEN WHEELS), FT
ZF       HEIGHT OF CG ABOVE FRONT WHEEL SPIN AXES, FT
ZR       HEIGHT OF CG ABOVE REAR  WHEEL SPIN AXES, FT
HF       FRONT WHEEL RADIUS, FT
HR       REAR  WHEEL RADIUS, FT
KF       SPRING LOAD-DEFLECTION RATE AT EACH FRONT WHEEL, LB/FT
KR       SPRING LOAD-DEFLECTION RATE AT EACH REAR  WHEEL, LB/FT
CF       VISCOUS DAMPING COEFFIENT AT EACH FRONT WHEEL, LB/FT/SEC
CR       VISCOUS DAMPING COEFFIENT AT EACH REAR  WHEEL, LB/FT/SEC
MUXF     CIRCUMFERENTIAL COEFFIENT OF FRICTION FOR EACH FRONT TIRE, LB/LB
MUXR     CIRCUMFERENTIAL COEFFIENT OF FRICTION FOR EACH REAR  TIRE, LB/LB
MUYF     MAXIMUM SIDE FORCE COEFFIENT OF FRICTION FOR EACH FRONT TIRE, LB/LB
MUYR     MAXIMUM SIDE FORCE COEFFIENT OF FRICTION FOR EACH REAR  TIRE, LB/LB
BETASF   SIDESLIP ANGLE AT WHICH SIDE FORCE SATURATES FOR EACH FRONT TIRE, DEG
BETASR   SIDESLIP ANGLE AT WHICH SIDE FORCE SATURATES FOR EACH REAR  TIRE, DEG
SNR      RELATIVE TIRE-ROAD SKID NUMBER (0 <= SNR <= 1)
```

FIGURE C-1. FILE 1 INPUT DATA (LABEL DATA)

KSW	FRONT-WHEEL-TO-STEERING-WHEEL TURN RATIO, DEG/DEG
KBF	BRAKE-TORQUE-TO-PEDAL-FORCE GAIN FOR EACH FRONT WHEEL, FT-LB/LB
KBR	BRAKE-TORQUE-TO-PEDAL-FORCE GAIN FOR EACH REAR WHEEL, FT-LB/LB
KSC	DRIVE-TORQUE-TO-VELOCITY-ERROR GAIN, FT-LB/FT/SEC (NOT NORMALLY USED)
UCMD	VEHICLE COMMAND SPEED, FT/SEC (NOT NORMALLY USED)
TDMAX	MAXIMUM DRIVE TORQUE, FT-LB (NOT NORMALLY USED)
------	DRIVER CONTROL MODEL PARAMETERS (OPEN AND CLOSED LOOP)
MANDEC	DRIVER MANEUVER DECISION MODE (0.=NONE, 1.=BRAKE, 2.=STEER, 3.=COMBIN
TAUR	DRIVER REACTION TIME, SEC
TAUP	DRIVER LEAD TIME-CONSTANT FOR LATERAL POSITION CONTROL, SEC
WC	DESCRIB. FUNCTION MODEL CROSSOVER FREQ. FOR HEAD. ERROR CONTROL, RAD/
VETH	LONGITUDINAL VEL ERROR THRESHOLD FOR CLOSED-LOOP BRAKING CONTROL, FT/
YETH	LATERAL POS. ERROR THRESHOLD FOR CLOSED-LOOP STEERING CONTROL, FT
ABR	NORMALIZED BRAKE INPUT RATE LIMIT (BRAKING AND COMBINED MAN.), 1/SEC
ABSTB	NORMALIZED BRAKE INPUT STEP AMPLITUDE LIMIT (BRAKING MANEUVER), %/10
ABSTC	NORMALIZED BRAKE INPUT STEP AMPLITUDE LIMIT (COMBINED MANEUVER), %/10
ASWS	SINUSOIDAL STEERING WHEEL INPUT AMPLITUDE (STEERING MANEUVER), DEG
ASWC	SINUSOIDAL STEERING WHEEL INPUT AMPLITUDE (COMBINED MANEUVER), DEG
TSW	SINUSOIDAL STEERING WHEEL INPUT PERIOD (STEERING AND COMBINED MAN.),
SWMAX	STEERING WHEEL AMPLITUDE LIMIT FOR CLOSED-LOOP STEERING CONTROL, DEG
SWRMAX	STEERING WHEEL RATE LIMIT FOR CLOSED-LOOP STEERING CONTROL, DEG/SEC
------	SCENARIO DEFINITION PARAMETERS
HOV	HEADWAY BETWEEN SUBJECT AND OBJECT VEHICLES, FT
UOVO	INITIAL VELOCITY OF OBJECT VEHICLE, MPH
DOVG	DECELERATION LEVEL OF OBJECT VEHICLE, G'S
HLV	HEADWAY BETWEEN OBJECT AND LEAD VEHICLES, FT
ULVO	INITIAL VELOCITY OF LEAD VEHICLE, MPH
DLVG	DECELERATION LEVEL OF LEAD VEHICLE, G'S
HNVMIN	MINIMUM HEADWAY BETWEEN ONCOMING VEHICLES, FT
HNVAVE	AVERAGE (MEAN) HEADWAY BETWEEN ONCOMING VEHICLES, FT
UNVO	VELOCITY OF ONCOMING VEHICLES, MPH
DISTSO	INITIAL DISTANCE FROM SUBJECT VEHICLE TO IMMINENT COLLISION POINT, FT
DISTNS	INITIAL DISTANCE FROM SUBJECT VEHICLE TO ONCOMING VEHICLE, FT
PSIB	INITIAL BEARING FROM SUBJECT VEHICLE TO OBJECT VEHICLE, DEG
LW	LANE WIDTH OF ROADWAY, FT
TAUD	CRITICAL EVENT DETECTION TIME FOR SUBJECT VEHICLE, SEC (FOR MDET=0)
TAUOVD	DRIVER RESPONSE DELAY TIME FOR OBJECT VEHICLE, SEC
------	DRIVER MANEUVER DECISION MODEL PARAMETERS
LAV	LENGTH OF ADJACENT LANE VEHICLES, FT
HAVMIN	MINIMUM HEADWAY BETWEEN ADJACENT LANE VEHICLES, FT
HAVAVE	AVERAGE (MEAN) HEADWAY BETWEEN ADJACENT LANE VEHICLES, FT
LF	LENGTH OF FRONT SAFE-MANEUVERING REGION FOR SUBJECT VEHICLE, FT
LR	LENGTH OF REAR SAFE-MANEUVERING REGION FOR SUBJECT VEHICLE, FT
PBO	APRIORI BRAKE MANEUVER PROBABILITY (0 <= PBO <= 1)
PSO	APRIORI STEER MANEUVER PROBABILITY (0 <= PSO <= 1)
PA	PROBABILITY THAT DRIVER IS AWARE OF ADJACENT TRAFFIC (0 <= PA <= 1)
TTHRSH	MANEUVER DECISN TIME THRESH (MIN. ACCEPT. TIME TO VERIFY ADJ. GAP),
DTHRSH	MANEUVER DECISN DIST. THRESH (MIN. ACCEPT. DIST. TO ONCOMING VEH.), F
TLOOK	TIME TO LOOK (CHECK) FOR ADJACENT VEHICLE, SEC
------	DRIVER EVENT DETECTION MODEL
ESKY	SKY ILLUMINATION ON VERT. SURFACE (EXCL EFFECTS OF DIR. SUNLIGHT), FT-
ESUN	SUN ILLUMINATION ON SURFACE NORMAL TO SUN'S RAYS, FT-CD
RO	REFLECTANCE OF INTERSECTING VEHICLE SURFACE, %/100
EO	OBJECT ILLUMINANCE DUE TO FIXED ROADWAY LIGHTING, FT-CD (NIGHT ONLY)
IO	OBJECT LUMINOUSPINTENSITY IN DIRECTION OF SUBJECT VEHICLE DRIVER, CD
BSUNO	ANGLE OF INCIDENCE BETWEEN SUN'S RAYS AND NORMAL TO OBJECT SURFACE, D
RB	REFLECTANCE OF LENS WITH STOP LAMP OFF, %/100
EB	BACKGROUND ILLUMINANCE DUE TO FIXED ROADWAY LIGHTING, FT-CD (NIGHT ON
IB	BACKGROUND (LENS) LUM INTENSITY IN DIRECTION OF SUBJ. VEHICLE DRIVER,
BSUNB	ANGLE OF INCIDENCE BETWEEN SUN'S RAYS AND NORMAL TO BACKGROUND, DEG

FIGURE C-1. (continued)

```
LSKY     LUMINANCE OF HORIZON/SKY, FT-L
LSUR     EFFECTIVE LUMINANCE OF OBJECT SURROUNDINGS (EXCL EFFECTS OF GLARE), FT-L
TRANS    WINDSHIELD TRANSMITTANCE, %/100
KL       WINDSHIELD TRANSMITTANCE SCALE FACTOR FOR LOS TO LEAD VEHICLE
VO       VERTICAL   DIMENSION OF OBJECT AS VIEWED BY DRIVER, FT
HO       HORIZONTAL DIMENSION OF OBJECT AS VIEWED BY DRIVER, FT
PLITE    PROBABILITY OF LINE-OF-SIGHT TO LEAD VEHICLE STOP LAMP (0 <= PLITE <= 1)
HRTH     RELATIVE CHANGE IN HEADWAY DETECTABLE WITH NEAR CERTAINTY, %/100
HPER     ECCENTRICITY ANGLE AT WHICH HEADWAY CHANGE IS DETECTABLE, DEG
SIGC     STANDARD DEVIATION OF DETECTION PROBABILITY DISTRIBUTION
KV1      TIME CONSTANT FOR TRANSIENT ADAPTATION TO GLARE (LV FILT< LV INST), SEC
KV2      TIME CONSTANT FOR TRANSIENT ADAPTATION TO GLARE (LV FILT>=LV INST), SEC
ALPHMN   MINIMUM ANGLE LIMIT FOR AN AND AG IN VEILING LUMINANCE CALCULATIONS, DEG
HEYE     HEIGHT OF SUBJECT VEHICLE DRIVER'S EYES ABOVE ROADWAY, FT
HLITE    HEIGHT OF SUBJECT VEHICLE HEADLIGHTS ABOVE ROADWAY, FT
HOBJ     HEIGHT OF OBJECT ABOVE ROADWAY (STOP LAMP OR OTHER OBJECT), FT
TAUBM    MEAN DRIVER BLINK DURATION, SEC
TAUBS    STANDARD DEVIATION OF DRIVER BLINK DURATION, SEC
TAURDM   MEAN DRIVER RESPONSE DELAY, SEC
TAURDS   STANDARD DEVIATION OF DRIVER RESPONSE DELAY, SEC
------   COLLISION DETERMINATION ALGORITHM PARAMETERS
LSVF     DISTANCE FROM CG TO FRONT OF SUBJECT VEHICLE, FT
LSVR     DISTANCE FROM CG TO REAR  OF SUBJECT VEHICLE, FT
WSV      WIDTH OF SUBJECT VEHICLE, FT
LOV      LENGTH OF OBJECT VEHICLE, FT
WOV      WIDTH  OF OBJECT VEHICLE, FT
UHTH     LONGITUDINAL VELOCITY THRESHOLD USED FOR RUN TERMINATION, FT/SEC
VHTH     LATERAL      VELOCITY THRESHOLD USED FOR RUN TERMINATION, FT/SEC
******

R: T=0.19/1.19 15:39:12

C>
```

FIGURE C-1. (concluded)

```
  type     s5n data

YES, READ RUN CONDITION MODIFICATIONS FROM TELETYPE
5 1 1 1 6 0          / MSCEN, MNITE, MDET, MADJ, MVEH, MSTOR
2 2 18 14            / MPRT, NU, NX, NVAR
 2 2                 / NTRIAL, ISEED
.025 .5 .25 10.      / DT, DTPRT, DTSTOR, TMAX
 &PARAML

 UHO=40.,VHO=0.,WHO=0.,XO=0.,YO=0.,ZO=0.,
 WXO=0.,WYO=0.,WZO=0.,PHIO=0.,THEO=0.,PSIO=0.,

 WEIGHT=3771.,IXX=313.,IYY=1917.,IZZ=2405.,
 DF=4.11,DR=5.73,TF=2.49,TR=2.58,ZF=.9,ZR=.9,HF=1.1,HR=1.1,
 KF=1260.,KR=1440.,CF=52.,CR=100.,
 MUXF=.85,MUXR=.88,MUYF=.96,MUYR=1.02,BETASF=20.,BETASR=17.,SNR=1.0,
 KSW=.07,KBF=0.60,KBR=0.40,
 KSC=0.,UCMD=0.,TDMAX=0.,

 MANDEC=0.,TAUR=.2,TAUP=3.,WC=3.5,VETH=2.,YETH=2.,
 ABR=0.,ABSTB=0.75,ABSTC=0.60,ASWS=90.,ASWC=90.,TSW=1.5,SWMAX=720.,SWRMAX=60

 HOV=100.,UOVO=40.,DOVG=.5,
 HLV=100.,ULVO=40.,DLVG=.25,
 HNVMIN=30.,HNVAVE=1056.,UNVO=40.,
 DISTSO=0.,DISTNS=0.,PSIB=0.,
 LW=12.,TAUD=1.5,TAUOVD=1.5,

 LAV=20.,HAVMIN=0.,HAVAVE=0.,
 LF=15.,LR=15.,PBO=.4,PSO=.08,PA=0.,
 TTHRSH=0.,DTHRSH=1076.,TLOOK=0.,

 ESKY=0.,ESUN=0.,RO=0.,EO=0.,IO=70.,BSUNO=0.,
 RB=0.,EB=0.,IB=2.,BSUNB=0.,LSKY=0.1,LSUR=0.3,
 TRANS=0.7,KL=0.5,VO=0.33,HO=0.33,PLITE=0.2,HRTH=0.12,HPER=10.0,
 SIGC=0.5,KV1=6.7,KV2=6.7,ALPHMN=0.5,
 HEYE=4.5,HLITE=2.5,HOBJ=2.5,TAUBM=0.16,TAUBS=0.,TAURDM=1.0,TAURDS=0.37,

 LSVF=7.,LSVR=7.,WSV=5.5,LOV=14.,WOV=5.5,
 UHTH=2.,VHTH=2.,
```

FIGURE C-2. SAMPLE INPUT DATA (SCENARIO 5, NIGHT)

```
&END
5           / NCAT
    .683     .17      2.12     -.26      2.92     1.36     1.68
    .053    5.        0.       40.       0.        .73      .33
    .022  -12.        0.      -52.       0.       1.08      .72
    .044  -18.        0.        0.       0.        .68      .27
    .005  -45.        0.       45.       0.       1.44      .50
2           / NGLARE
0.       0.       0.
0.       0.       0.
36          / NMERG
1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  .5  .5  1.  1.  1.  1.  1.
1.  1.  1.  1.  1.  .5  .25 .25 .25 .5  1.  1.  1.  1.  1.  1.  1.
11          / NPTD
     4     1000
     3     1000
     2     1000
     1     1300
     0     3000
    -1    11000
    -2    12000
    -3     7900
    -4     4000
    -5     1800
    -6     1000
11  6       / NPTXE, NPTYE
          -10     -9     -8     -7     -6     -5     -4     -3     -2     -1      0
     4   1000   1000   1000   1000   1000   1000   1000   1000   1000   1000   1000
     3   1000   1000   1000   1000   1000   1000   1000   1000   1000   1000   1000
     2   1000   1000   1000   1000   1000   1000   1000   1000   1000   1000   1000
     1   1000   1000   1000   1000   1000   1000   1000   1000   1000   1000   1300
     0   1900   1900   1900   1900   1900   1900   1900   1900   1900   1900   3000
    -1   3500   3500   3500   3500   3800   3900   4050   4200   5200   6500  11000
7  8        / NPTXF, NPTYF
        -3.66 -2.66 -1.66 -0.66  0.34  1.34  2.34
    -3   2.98  2.00  1.27  0.81  0.62  0.46  0.37
    -2   2.09  1.12  0.37  0.01 -0.20 -0.33 -0.39
    -1   1.37  0.42 -0.29 -0.68 -0.87 -0.96 -1.03
     0   0.82 -0.14 -0.78 -1.08 -1.25 -1.34 -1.37
     1   0.42 -0.49 -0.98 -1.22 -1.34 -1.41 -1.44
     2   0.11 -0.73 -1.13 -1.30 -1.39 -1.45 -1.47
     3  -0.03 -0.84 -1.20 -1.35 -1.42 -1.47 -1.49
     4  -0.10 -0.90 -1.24 -1.38 -1.44 -1.48 -1.50
```

---

*Not needed for this run. Could be replaced with

```
0        / NGLARE
0        / NMERG
0        / NPTD
0 0      / NPTXE, NPTYE
```

FIGURE C-2. (continued)

```
 7 27          / NPTXG, NPTYG
              -3.66  -2.66  -1.66  -0.66   0.34   1.34   2.34
       0       0.00   0.00   0.00   0.00   0.00   0.00   0.00
       1       0.25   0.21   0.12   0.08   0.05   0.02   0.00
       2       0.43   0.39   0.21   0.13   0.09   0.05   0.01
       3       0.56   0.51   0.28   0.19   0.13   0.07   0.02
       4       0.66   0.61   0.35   0.24   0.17   0.10   0.03
       5       0.74   0.69   0.41   0.29   0.22   0.14   0.06
       6       0.81   0.76   0.47   0.34   0.26   0.18   0.09
       7       0.87   0.81   0.52   0.39   0.30   0.21   0.12
       8       0.92   0.86   0.58   0.44   0.34   0.25   0.15
       9       0.97   0.91   0.63   0.48   0.38   0.28   0.18
      10       1.02   0.97   0.68   0.52   0.42   0.32   0.22
      15       1.25   1.20   0.91   0.74   0.63   0.51   0.39
      20       1.49   1.44   1.15   0.97   0.84   0.70   0.56
      25       1.73   1.68   1.38   1.19   1.04   0.89   0.74
      30       1.96   1.91   1.61   1.42   1.25   1.08   0.91
      35       2.20   2.14   1.85   1.63   1.45   1.27   1.09
      40       2.44   2.37   2.08   1.85   1.66   1.46   1.26
      45       2.67   2.61   2.32   2.07   1.86   1.65   1.44
      50       2.91   2.84   2.55   2.30   2.07   1.84   1.61
      55       3.14   3.08   2.79   2.52   2.27   2.03   1.79
      60       3.38   3.31   3.02   2.72   2.48   2.22   1.96
      65       3.62   3.54   3.25   2.96   2.69   2.41   2.13
      70       3.85   3.78   3.49   3.18   2.89   2.60   2.31
      75       4.09   4.01   3.72   3.41   3.10   2.79   2.48
      80       4.32   4.25   3.96   3.63   3.30   2.98   2.66
      85       4.56   4.48   4.19   3.85   3.51   3.17   2.83
      90       4.80   4.71   4.42   4.07   3.72   3.36   3.00
2 0          / NIVG, NSTOR
8 2          / NIV(1), ND(1)
'UHO'      40.    55.
'UDVO'     40.    55.
'ULVO'     40.    55.
'UNVO'     40.    55.
'HNVMIN'   30.    40.
'HNVAVE'   1056.  1056.
'DTHRSH'   1076.  1392.
'TSW'      1.5    1.1
1 3          / NIV(2), ND(2)
'HDV'      35.    70.    105.
3            / NRV
'ABSTB'    1 0.25   0.75
'ABSTC'    1 0.25   0.60
'SNR'      5 0.     0.
 4
  0.   .2   .8   1.
  0.   .1   .8   1.

R; T=0.28/1.54 17:17:43

C>
```

FIGURE C-2. (concluded)

```
run
>s5n
FILEDEF 1 DISK LABEL DATA
FILEDEF 2 DISK S5N DATA
FILEDEF 7 DISK TERMINAL DATA A ( RECFM FA LRECL 120 BLOCK 120 )
FILEDEF 8 DISK SUMMARY DATA A ( RECFM FA LRECL 120 BLOCK 120 )
FILEDEF 9 DISK DETAILED DATA A ( RECFM FA LRECL 120 BLOCK 120 )
FILEDEF 10 DISK TRAJECTO DATA
DRIVEM


PROGRAM CONTROL PARAMETERS

  SCENARIO  5 : FOLLOWING, URBAN STREET, INTERVENING VEHICLE

  DAY/NIGHT MODE : 1 (NIGHT)

  EVENT DETECTION MODE : 1 (EVENT DET. MODEL)

  ADJACENT LANE TRAFFIC MODE : 1 (NORMAL TRAFFIC   )

  VEHICLE MODEL ORDER : 6 (6 DOF)

  TRAJECTORY DATA STORAGE MODE : 0 (NO STORAGE        )

  DATA PRINTOUT CONTROL MODE : 2 (IND. TIME HIST. )     (NU =  2, NX = 18, NVAR = 14)

  NUMBER OF MONTE CARLO TRIALS :      2

  RANDOM NUMBER GENERATOR SEED :    2

  TIME PARAMETERS : INTEGRATION STEP = 0.025, PRINT STEP = 0.500, STORAGE STEP = 0.250, MAXIMUM RUN TIME = 10.000

DO YOU WISH TO MODIFY PROGRAM CONTROL PARAMETERS?
>y


TYPE IN APPROPRIATE RESPONSE TO EACH OF THE FOLLOWING QUESTIONS.
ALL RESPONSES SHOULD BE NUMERIC WITH THE EXCEPTIONS :
          / = NO CHANGE FROM NOMINAL
         -1 = NEED MORE INFORMATION
         -2 = NO FURTHER PROGRAM CONTROL PARAMETER CHANGES DESIRED
```

FIGURE C-3. SAMPLE OF PROGRAM CONTROL PARAMETER MODIFICATIONS FROM TERMINAL (DEVICES 5 AND 6)

```
  SCENARIO NUMBER?
?
>-1
     CORRECT RESPONSES ARE :
         0 = NONE
         1 = FOLLOWING, FREEWAY
         2 = FOLLOWING, FREEWAY, INTERVENING VEHICLE
         3 = FOLLOWING, FREEWAY ENTRANCE RAMP
         4 = FOLLOWING, URBAN STREET
         5 = FOLLOWING, URBAN STREET, INTERVENING VEHICLE
         6 = LATERALLY MOVING VEHICLE, FREEWAY ENTRANCE RAMP
         7 = LATERALLY MOVING VEHICLE, INTERSECTION, VEHICLE APPROACH FROM RI
         8 = LATERALLY MOVING VEHICLE, INTERSECTION, VEHICLE APPROACH FROM LEF
         9 = OBJECT ON ROADWAY, PEDESTRIAN MOVES FROM CONCEALED POSITION
        10 = STATIONARY OBJECT ON ROADWAY
        11 = STATIONARY OBJECT ON ROADWAY, ONCOMING VEHICLE
  SCENARIO NUMBER?
?
>/
  DAY/NIGHT MODE?
?
>-1
     CORRECT RESPONSES ARE :
         0 =  DAY
         1 = NIGHT
  DAY/NIGHT MODE?
?
>/
  EVENT DETECTION MODE?
?
>-1
     CORRECT RESPONSES ARE :
         0 = PURE TIME DELAY
         1 = EVENT DET. MODEL
  EVENT DETECTION MODE?
?
>/
  ADJACENT LANE TRAFFIC MODE?
?
>-1
     CORRECT RESPONSES ARE :
         0 = NONE
         1 = NORMAL TRAFFIC
  ADJACENT LANE TRAFFIC MODE?
?
>/
  VEHICLE MODEL ORDER?
?
>-1
     CORRECT RESPONSES ARE :
         0 = NONE
         1 = 1 DOF
         2 = 2 DOF
         3 = 3 DOF
         4 = 6 DOF
         5 = 6 DOF
         6 = 6 DOF
  VEHICLE MODEL ORDER?
?
```

FIGURE C-3. (continued)

```
>/
  VEHICLE TRAJECTORY DATA STORAGE MODE?
?
>-1
    CORRECT RESPONSES ARE :
       0 = NO STORAGE
       1 = STORE DATA
       2 = RECALL DATA
  VEHICLE TRAJECTORY DATA STORAGE MODE?
?
>/
  DATA PRINTOUT CONTROL MODE?
?
>-1
    CORRECT RESPONSES ARE :
       0 = OVERALL SUMMARY
       1 = IND. RUN SUMMARY
       2 = IND. TIME HIST.
  DATA PRINTOUT CONTROL MODE?
?
>/
  NUMBER OF CONTROL INPUTS FOR TIME HISTORY (0-2)?
?
>-1
  NUMBER OF CONTROL INPUTS FOR TIME HISTORY (0-2)?
?
>/
  NUMBER OF STATE VARIABLES FOR TIME HISTORY (0-18)?
?
>-1
  NUMBER OF STATE VARIABLES FOR TIME HISTORY (0-18)?
?
>/
  NUMBER OF INTERMEDIATE VARIABLES FOR TIME HISTORY (0-54)?
?
>-1
  NUMBER OF INTERMEDIATE VARIABLES FOR TIME HISTORY (0-54)?
?
>/
  NUMBER OF MONTE CARLO TRIALS (>=0)?
?
>-1
  NUMBER OF MONTE CARLO TRIALS (>=0)?
?
>/
  RANDOM NUMBER GENERATOR SEED (0-13)?
?
>-1
  RANDOM NUMBER GENERATOR SEED (0-13)?
?
>/
  INTEGRATION TIME STEP FOR DRIVER/VEHICLE SIMULATION (>0.0)?
?
>-1
***** INTEGRATION TIME STEP  DT = -1.000000  IS LESS THAN OR EQUAL TO ZERO *****
  INTEGRATION TIME STEP FOR DRIVER/VEHICLE SIMULATION (>0.0)?
?
>/
  TIME STEP FOR TIME HISTORY PRINTOUT (MULTIPLE OF INTEGRATION STEP)?
?
```

FIGURE C-3. (continued)

```
>-1
***** TIME-HISTORY PRINTOUT TIME STEP  DTPRT = -1.000000  IS LESS THAN ZERO *****
  TIME STEP FOR TIME HISTORY PRINTOUT (MULTIPLE OF INTEGRATION STEP)?
?
>  /
  SAMPLE TIME STEP FOR VEHICLE TRAJECTORY STORAGE (MULTIPLE OF INTEGRATION STEP)?
?
>-1
***** DATA STORAGE TIME STEP  DTSTOR = -1.000000  IS LESS THAN ZERO *****
  SAMPLE TIME STEP FOR VEHICLE TRAJECTORY STORAGE (MULTIPLE OF INTEGRATION STEP)?
?
>/
  MAXIMUM RUN TIME FOR EACH MONTE CARLO ITERATION?
?
>-1
***** MAXIMUM RUN TIME  TMAX = -1.000000  IS LESS THAN ZERO *****
  MAXIMUM RUN TIME FOR EACH MONTE CARLO ITERATION?
?
>    /


PROGRAM CONTROL PARAMETERS

  SCENARIO  5 : FOLLOWING, URBAN STREET, INTERVENING VEHICLE

  DAY/NIGHT MODE : 1 (NIGHT)

  EVENT DETECTION MODE : 1 (EVENT DET. MODEL)

  ADJACENT LANE TRAFFIC MODE : 1 (NORMAL TRAFFIC  )

  VEHICLE MODEL ORDER : 6 (6 DOF)

  TRAJECTORY DATA STORAGE MODE : 0 (NO STORAGE       )

  DATA PRINTOUT CONTROL MODE : 2 (IND. TIME HIST. )     (NU =  2, NX = 18, NVAR = 14)

  NUMBER OF MONTE CARLO TRIALS :     2

  RANDOM NUMBER GENERATOR SEED :   2

  TIME PARAMETERS : INTEGRATION STEP = 0.025, PRINT STEP = 0.500, STORAGE STEP = 0.250, MAXIMUM RUN TIME = 10.000
```

FIGURE C-3. (continued)

```
DO YOU WISH TO MODIFY PROGRAM CONTROL PARAMETERS?
>n
                         •
                         •
                         •

DO YOU WISH TO INCREASE NUMBER OF MONTE CARLO TRIALS?
>y

TYPE IN TOTAL NUMBER OF MONTE CARLO TRIALS DESIRED
?
>1000
                         •
                         •
                         •
```

FIGURE C-3. (concluded)

```
type terminal data


PROGRAM CONTROL PARAMETERS

  SCENARIO  5 : FOLLOWING, URBAN STREET, INTERVENING VEHICLE

  DAY/NIGHT MODE : 1 (NIGHT)

  EVENT DETECTION MODE : 1 (EVENT DET. MODEL)

  ADJACENT LANE TRAFFIC MODE : 1 (NORMAL TRAFFIC  )

  VEHICLE MODEL ORDER : 6 (6 DOF)

  TRAJECTORY DATA STORAGE MODE : 0 (NO STORAGE      )

  DATA PRINTOUT CONTROL MODE : 2 (IND. TIME HIST. )     (NU =  2, NX = 18, NVAR = 14)

  NUMBER OF MONTE CARLO TRIALS :      2

  RANDOM NUMBER GENERATOR SEED :    2

  TIME PARAMETERS : INTEGRATION STEP = 0.025, PRINT STEP = 0.500, STORAGE STEP = 0.250, MAXIMUM RUN TIME = 10.000

DO YOU WISH TO MODIFY PROGRAM CONTROL PARAMETERS?
N


INDEPENDENT VARIABLES ( 2 GROUPS, 0 LEVELS OF STORAGE)

  GROUP 1 ( 8 VARIABLES,  2 LEVELS)

    UHO        40.00000  55.00000
    UOVO       40.00000  55.00000
    ULVO       40.00000  55.00000
    UNVO       40.00000  55.00000
    HNVMIN     30.00000  40.00000
    HNVAVE   1056.000001056.00000
    DTHRSH   1076.000001392.00000
    TSW         1.50000   1.10000
```

FIGURE C-4. SAMPLE TERMINAL OUTPUT (FILE 7)

```
GROUP 2 ( 1 VARIABLES,  3 LEVELS)

  HOV        35.00000  70.00000 105.00000


RANDOM VARIABLES
ABSTB           1     0.25000    0.75000
ABSTC           1     0.25000    0.60000
SNR             5     0.0        0.0
                0.0         0.20000    0.80000    1.00000
                0.0         0.10000    0.80000    1.00000
```

OVERALL RUN SUMMARY FOR 2 TRIALS

INDEPENDENT VARIABLES UHO	INDEPENDENT VARIABLES HOV	MANEUVER PROBABILITIES BRAKE	MANEUVER PROBABILITIES STEER	MANEUVER PROBABILITIES COMB.	NUMBER OF COLLISIONS FWD.	NUMBER OF COLLISIONS LAT.	IMPACT VELOCITY MEAN	IMPACT VELOCITY ST DEV	PROBABILITY OF COLLISION	95 PERCENT CONFIDENCE LIMITS
40.0000	35.0000	1.0000	0.0	0.0	2	0	13.20	4.07	1.0000	(0.3424, 1.0000)
40.0000	70.0000	0.5000	0.0	0.5000	2	0	26.21	3.58	1.0000	(0.3424, 1.0000)
40.0000	105.0000	1.0000	0.0	0.0	1	0	32.76	0.0	0.5000	(0.0945, 0.9055)
55.0000	35.0000	1.0000	0.0	0.0	2	0	11.03	2.92	1.0000	(0.3424, 1.0000)
55.0000	70.0000	1.0000	0.0	0.0	1	0	28.53	0.0	0.5000	(0.0945, 0.9055)
55.0000	105.0000	0.5000	0.0	0.5000	1	0	35.72	0.0	0.5000	(0.0945, 0.9055)

```
DO YOU WISH TO INCREASE NUMBER OF MONTE CARLO TRIALS?
N

R; T=0.13/0.60 16:27:10

C>
```

FIGURE C-4. (concluded)

```
type summary data

 UHO    =    40.0000    HOV    =    35.0000

 TRIAL  TIME      UH       VH        X         Y       PSI       UOV      XOV       ULV      XLV       UNV       XNV   MDEC COLLF  DELV

   1    4.25    20.09     0.0    209.61      0.0      0.0       9.77   223.51     16.65   311.73     40.00  1450.04    1     1    10.32
   2    3.22    37.21     0.0    186.39      0.0      0.0      21.14   200.04     22.34   282.12     40.00  2799.66    1     1    16.03

    RV       MEAN      SIGMA
ABSTB      0.3936     0.0146
ABSTC      0.4499     0.1435
SNR        0.5555     0.3483

*************************************************************************************************************************

 UHO    =    40.0000    HOV    =    70.0000

 TRIAL  TIME      UH       VH        X         Y       PSI       UOV P    XOV       ULV      XLV       UNV       XNV   MDEC COLLF  DELV

   1    4.42    31.62     0.0    247.32      0.0      0.0       7.93   260.58     15.73   350.70     40.00  1314.89    1     1    23.68
   2    4.14    39.72     0.0    243.12      0.0      0.0      10.07   256.84     17.25   344.00     40.00  2080.72    3     1    28.75

    RV       MEAN      SIGMA
ABSTB      0.5175     0.0312
ABSTC      0.5259     0.1028
SNR        0.5163     0.0917

*************************************************************************************************************************

 UHO    =    40.0000    HOV    =   105.0000

 TRIAL  TIME      UH       VH        X         Y       PSI       UOV      XOV       ULV      XLV       UNV       XNV   MDEC COLLF  DELV

   1    5.93     1.32     0.0    255.31      0.0      0.0       0.00   299.89      7.46   411.34     40.00   607.64    1     0     0.0
   2    5.18    32.76     0.0    236.05      0.0      0.0       0.00   299.89     11.54   400.97     40.00  1836.13    1     1    32.76

    RV       MEAN      SIGMA
ABSTB      0.4303     0.1227
ABSTC      0.4706     0.1304
SNR        0.6460     0.4742

*************************************************************************************************************************

 UHO    =    55.0000    HOV    =    35.0000

 TRIAL  TIME      UH       VH        X         Y       PSI       UOV      XOV       ULV      XLV       UNV       XNV   MDEC COLLF  DELV

   1    3.53    45.37     0.0    272.57      0.0      0.0      32.77   286.35     35.65   369.35     55.00   463.22    1     1    13.10
   2    3.72    39.54     0.0    231.92      0.0      0.0      30.58   295.63     34.56   379.63     55.00   510.28    1     1     8.96
```

FIGURE C-5. SAMPLE INDIVIDUAL RUN SUMMARIES (FILE 8)

```
ABSTB      0.4313     0.1217
ABSTC      0.4735     0.1304
STR        0.5451     0.4742

****************************************************************************************************

 UHO   =    55.0000    HOV    =    35.0000

TRIAL  TIME     UH       VH       X        Y       PSI     UOV      XOV      ULV      XLV      UNV      XNV    MDEC COLLF  DELV

  1    3.53    45.87     0.0   272.57     0.0     0.0    32.77   286.35   35.65   369.35   55.00   463.22    1     1    13.10
  2    3.72    39.54     0.0   231.72     0.0     0.0    30.53   295.53   34.55   379.53   55.00   510.28    1     1     8.96

   RV        MEAN       SIGMA
ABSTB      0.5419     0.1547
ABSTC      0.5065     0.1278
STR        0.5712     1.3939

****************************************************************************************************

 UHO   =    55.0000    HOV    =    70.0000

TRIAL  TIME     UH       VH       X        Y       PSI     UOV      XOV      ULV      XLV      UNV      XNV    MDEC COLLF  DELV

  1    4.19    53.93     0.0   336.35     0.0     0.0    25.44   349.33   31.99   437.44   55.00   634.18    1     1    28.53
  2    4.43     1.20     0.0   332.75     0.0     0.0     5.63   393.06   19.58   522.94   55.00  1434.39    1     0     0.0

   RV        MEAN       SIGMA
ABSTB      0.5224     0.1038
ABSTC      0.4760     0.0854
STR        0.4512     0.5453

****************************************************************************************************

 UHO   =    55.0000    HOV    =   105.0000

TRIAL  TIME     UH       VH       X        Y       PSI     UOV      XOV      ULV      XLV      UNV      XNV    MDEC COLLF  DELV

  1    6.36    36.33    -0.22  443.11   -12.31   -0.09     1.62   427.91   20.03   555.31   55.00  1946.05    3     0     0.0
  2    4.33    53.62     0.0   392.92     0.0     0.0    17.89   406.69   28.21   502.81   55.00   760.36    1     1    35.72

   RV        MEAN       SIGMA
ABSTB      0.4317     0.2034
ABSTC      0.3448     0.1057
STR        0.4641     0.1389

****************************************************************************************************

R; T=0.14/0.63 16:28:18

C>
```

FIGURE C-5. (concluded)

```
type detailed data

NOMINAL SIMULATION PARAMETER VALUES

  INITIAL CONDITIONS (SUBJECT VEHICLE)

    UHO       40.00        INITIAL LONG. VELOCITY OF CG IN HORIZONTAL BODY AXES, MPH (+ FORWARD)
    VHO       .0           INITIAL LAT.  VELOCITY OF CG IN HORIZONTAL BODY AXES, MPH (+ RIGHT)
    WHO       .0           INITIAL VERT. VELOCITY OF CG IN HORIZONTAL BODY AXES, MPH (+ DOWN)
    XO        .0           INITIAL LONG. POSITION OF CG IN INERTIAL AXES, FT (+ FORWARD)
    YO        .0           INITIAL LAT.  POSITION OF CG IN INERTIAL AXES, FT (+ RIGHT)
    ZO        .0           INITIAL VERT. POSITION OF CG IN INERTIAL AXES, FT (+ DOWN)
    WXO       .0           INITIAL ANGULAR RATE ABOUT X BODY AXIS, DEG/SEC (+ CLOCKWISE)
    WYO       .0           INITIAL ANGULAR RATE ABOUT Y BODY AXIS, DEG/SEC (+ CLOCKWISE)
    WZO       .0           INITIAL ANGULAR RATE ABOUT Z BODY AXIS, DEG/SEC (+ CLOCKWISE)
    PHIO      .0           INITIAL ROLL  ATTITUDE, DEG (+CLOCKWISE)
    THEO      .0           INITIAL PITCH ATTITUDE, DEG (+CLOCKWISE)
    PSIO      .0           INITIAL YAW   ATTITUDE, DEG (+CLOCKWISE)

  VEHICLE MODEL PARAMETERS (SUBJECT VEHICLE)

    WEIGHT    3771.        VEHICLE WEIGHT, LB
    IXX       313.0        ROLL  PRINCIPAL MOMENT OF INERTIA ABOUT X BODY AXIS, FT-LB-SEC**2
    IYY       1917.        PITCH PRINCIPAL MOMENT OF INERTIA ABOUT Y BODY AXIS, FT-LB-SEC**2
    IZZ       2405.        YAW   PRINCIPAL MOMENT OF INERTIPPABOUT Z BODY AXIS, FT-LB-SEC**2
    DF        4.110        DISTANCE FROM CG TO SPIN AXES OF FRONT WHEELS, FT
    DR        5.730        DISTANCE FROM CG TO SPIN AXES OF REAR  WHEELS, FT
    TF        2.490        HALF TREAD WIDTH OF FRONT WHEELS (HALF OF DISTANCE BETWEEN WHEELS), FT
    TR        2.580        HALF TREAD WIDTH OF REAR  WHEELS (HALF OF DISTANCE BETWEEN WHEELS), FT
    ZF        .9000        HEIGHT OF CG ABOVE FRONT WHEEL SPIN AXES, FT
    ZR        .9000        HEIGHT OF CG ABOVE REAR  WHEEL SPIN AXES, FT
    HF        1.100        FRONT WHEEL RADIUS, FT
    HR        1.100        REAR  WHEEL RADIUS, FT
    KF        1260.        SPRING LOAD-DEFLECTION RATE AT EACH FRONT WHEEL, LB/FT
    KR        1440.        SPRING LOAD-DEFLECTION RATE AT EACH REAR  WHEEL, LB/FT
    CF        52.00        VISCOUS DAMPING COEFFIENT AT EACH FRONT WHEEL, LB/FT/SEC
    CR        100.0        VISCOUS DAMPING COEFFIENT AT EACH REAR  WHEEL, LB/FT/SEC
    MUXF      .8500        CIRCUMFERENTIAL COEFFIENT OF FRICTION FOR EACH FRONT TIRE, LB/LB
    MUXR      .8800        CIRCUMFERENTIAL COEFFIENT OF FRICTION FOR EACH REAR  TIRE, LB/LB
    MUYF      .9600        MAXIMUM SIDE FORCE COEFFIENT OF FRICTION FOR EACH FRONT TIRE, LB/LB
    MUYR      1.020        MAXIMUM SIDE FORCE COEFFIENT OF FRICTION FOR EACH REAR  TIRE, LB/LB
    BETASF    20.00        SIDESLIP ANGLE AT WHICH SIDE FORCE SATURATES FOR EACH FRONT TIRE, DEG
    BETASR    17.00        SIDESLIP ANGLE AT WHICH SIDE FORCE SATURATES FOR EACH REAR  TIRE, DEG
    SNR       1.000        RELATIVE TIRE-ROAD SKID NUMBER (0 <= SNR <= 1)
    KSW       .7000E-01    FRONT-WHEEL-TO-STEERING-WHEEL TURN RATIO, DEG/DEG
    KBF       .6000        BRAKE-TORQUE-TO-PEDAL-FORCE GAIN FOR EACH FRONT WHEEL, FT-LB/LB
    KBR       .4000        BRAKE-TORQUE-TO-PEDAL-FORCE GAIN FOR EACH REAR  WHEEL, FT-LB/LB
    KSC       .0           DRIVE-TORQUE-TO-VELOCITY-ERROR GAIN, FT-LB/FT/SEC (NOT NORMALLY USED)
    UCMD      .0           VEHICLE COMMAND SPEED, FT/SEC (NOT NORMALLY USED)
    TDMAX     .0           MAXIMUM DRIVE TORQUE, FT-LB (NOT NORMALLY USED)
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FIGURE C-6. SAMPLE DETAILED OUTPUT DATA (FILE 9)

DRIVER CONTROL MODEL PARAMETERS (OPEN AND CLOSED LOOP)

MANDEC	.0	DRIVER MANEUVER DECISION MODE (0.=NONE, 1.=BRAKE, 2.=STEER, 3.=COMBINED)
TAUR	.2000	DRIVER REACTION TIME, SEC
TAUP	3.000	DRIVER LEAD TIME-CONSTANT FOR LATERAL POSITION CONTROL, SEC
WC	3.500	DESCRIB. FUNCTION MODEL CROSSOVER FREQ. FOR HEAD. ERROR CONTROL, RAD/SEC
VETH	2.000	LONGITUDINAL VEL ERROR THRESHOLD FOR CLOSED-LOOP BRAKING CONTROL, FT/SEC
YETH	2.000	LATERAL POS. ERROR THRESHOLD FOR CLOSED-LOOP STEERING CONTROL, FT
ABR	.0	NORMALIZED BRAKE INPUT RATE LIMIT (BRAKING AND COMBINED MAN.), 1/SEC
ABSTB	.7500	NORMALIZED BRAKE INPUT STEP AMPLITUDE LIMIT (BRAKING MANEUVER), %/100
ABSTC	.6000	NORMALIZED BRAKE INPUT STEP AMPLITUDE LIMIT (COMBINED MANEUVER), %/100
ASWS	90.00	SINUSOIDAL STEERING WHEEL INPUT AMPLITUDE (STEERING MANEUVER), DEG
ASWC	90.00	SINUSOIDAL STEERING WHEEL INPUT AMPLITUDE (COMBINED MANEUVER), DEG
TSW	1.500	SINUSOIDAL STEERING WHEEL INPUT PERIOD (STEERING AND COMBINED MAN.), SEC
SWMAX	720.0	STEERING WHEEL AMPLITUDE LIMIT FOR CLOSED-LOOP STEERING CONTROL, DEG
SWRMAX	600.0	STEERING WHEEL RATE LIMIT FOR CLOSED-LOOP STEERING CONTROL, DEG/SEC

SCENARIO DEFINITION PARAMETERS

HOV	100.0	HEADWAY BETWEEN SUBJECT AND OBJECT VEHICLES, FT
VOVO	40.00	INITIAL VELOCITY OF OBJECT VEHICLE, MPH
DOVG	.5000	DECELERATION LEVEL OF OBJECT VEHICLE, G'S
HLV	100.0	HEADWAY BETWEEN OBJECT AND LEAD VEHICLES, FT
VLVO	40.00	INITIAL VELOCITY OF LEAD VEHICLE, MPH
DLVG	.2500	DECELERATION LEVEL OF LEAD VEHICLE, G'S
HNVMIN	30.00	MINIMUM HEADWAY BETWEEN ONCOMING VEHICLES, FT
HNVAVE	1056.	AVERAGE (MEAN) HEADWAY BETWEEN ONCOMING VEHICLES, FT
VNVO	40.00	VELOCITY OF ONCOMING VEHICLES, MPH
DISTSO	.0	INITIAL DISTANCE FROM SUBJECT VEHICLE TO IMMINENT COLLISION POINT, FT
DISTNS	.0	INITIAL DISTANCE FROM SUBJECT VEHICLE TO ONCOMING VEHICLE, FT
PSI3	.0	INITIAL BEARING FROM SUBJECT VEHICLE TO OBJECT VEHICLE, DEG
LW	12.00	LANE WIDTH OF ROADWAY, FT
TAUD	1.500	CRITICAL EVENT DETECTION TIME FOR SUBJECT VEHICLE, SEC (FOR MDET=0)
TAUOVD	1.500	DRIVER RESPONSE DELAY TIME FOR OBJECT VEHICLE, SEC

FIGURE C-6. (continued)

DRIVER MANEUVER DECISION MODEL PARAMETERS

LAV	20.00	LENGTH OF ADJACENT LANE VEHICLES, FT
HAVMIN	.0	MINIMUM HEADWAY BETWEEN ADJACENT LANE VEHICLES, FT
HAVAVE	.0	AVERAGE (MEAN) HEADWAY BETWEEN ADJACENT LANE VEHICLES, FT
LF	15.00	LENGTH OF FRONT SAFE-MANEUVERING REGION FOR SUBJECT VEHICLE, FT
LR	15.00	LENGTH OF REAR SAFE-MANEUVERING REGION FOR SUBJECT VEHICLE, FT
PBO	.4000	APRIORI BRAKE MANEUVER PROBABILITY (0 <= PBO <= 1)
PSO	.8000E-01	APRIORI STEER MANEUVER PROBABILITY (0 <= PSO <= 1)
PA	.0	PROBABILITY THAT DRIVER IS AWARE OF ADJACENT TRAFFIC (0 <= PA <= 1)
TTHRSH	.0	MANEUVER DECISN TIME THRESH (MIN. ACCEPT. TIME TO VERIFY ADJ. GAP), SEC
DTHRSH	1076.	MANEUVER DECISN DIST. THRESH (MIN. ACCEPT. DIST. TO ONCOMING VEH.), FT
TLOOK	.0	TIME TO LOOK (CHECK) FOR ADJACENT VEHICLE, SEC

DRIVER EVENT DETECTION MODEL

ESKY	.0	SKY ILLUMINATION ON VERT. SURFACE (EXCL EFFECTS OF DIR. SUNLIGHT), FT-CD
ESUN	.0	SUN ILLUMINATION ON SURFACE NORMAL TO SUN'S RAYS, FT-CD
RO	.0	REFLECTANCE OF INTERSECTING VEHICLE SURFACE, %/100
EO	.0	OBJECT ILLUMINANCE DUE TO FIXED ROADWAY LIGHTING, FT-CD (NIGHT ONLY)
IO	70.00	OBJECT LUMINOUS INTENSITY IN DIRECTION OF SUBJECT VEHICLE DRIVER, CD
BSUNO	.0	ANGLE OF INCIDENCE BETWEEN SUN'S RAYS AND NORMAL TO OBJECT SURFACE, DEG
RB	.0	REFLECTANCE OF LENS WITH STOP LAMP OFF, %/100
EB	.0	BACKGROUND ILLUMINANCE DUE TO FIXED ROADWAY LIGHTING, FT-CD (NIGHT ONLY)
IB	2.000	BACKGROUND (LENS) LUM INTENSITY IN DIRECTION OF SUBJ. VEHICLE DRIVER, CD
BSUNB	.0	ANGLE OF INCIDENCE BETWEEN SUN'S RAYS AND NORMAL TO BACKGROUND, DEG
LSKY	.1000	LUMINANCE OF HORIZON/SKY, FT-L
LSUR	.3000	EFFECTIVE LUMINANCE OF OBJECT SURROUNDINGS (EXCL EFFECTS OF GLARE), FT-L
TRANS	.7000	WINDSHIELD TRANSMITTANCE, %/100
KL	.5000	WINDSHIELD TRANSMITTANCE SCALE FACTOR FOR LOS TO LEAD VEHICLE
VO	.3300	VERTICAL DIMENSION OF OBJECT AS VIEWED BY DRIVER, FT
HO	.3300	HORIZONTAL DIMENSION OF OBJECT AS VIEWED BY DRIVER, FT
PLITE	.2000	PROBABILITY OF LINE-OF-SIGHT TO LEAD VEHICLE STOP LAMP (0 <= PLITE <= 1)
HRTH	.1200	RELATIVE CHANGE IN HEADWAY DETECTABLE WITH NEAR CERTAINTY, %/100
HPER	10.00	ECCENTRICITY ANGLE AT WHICH HEADWAY CHANGE IS DETECTABLE, DEG
SIGC	.5000	STANDARD DEVIATION OF DETECTION PROBABILITY DISTRIBUTION
KV1	6.700	TIME CONSTANT FOR TRANSIENT ADAPTATION TO GLARE (LV FILT< LV INST), SEC
KV2	6.700	TIME CONSTANT FOR TRANSIENT ADAPTATION TO GLARE (LV FILT>=LV INST), SEC
ALPHMN	.5000	MINIMUM ANGLE LIMIT FOR AN AND AG IN VEILING LUMINANCE CALCULATIONS, DEG
HEYE	4.500	HEIGHT OF SUBJECT VEHICLE DRIVER'S EYES ABOVE ROADWAY, FT
HLITE	2.500	HEIGHT OF SUBJECT VEHICLE HEADLIGHTS ABOVE ROADWAY, FT
HOBJ	2.500	HEIGHT OF OBJECT ABOVE ROADWAY (STOP LAMP OR OTHER OBJECT), FT
TAUBM	.1600	MEAN DRIVER BLINK DURATION, SEC
TAUBS	.0	STANDARD DEVIATION OF DRIVER BLINK DURATION, SEC
TAURDM	1.000	MEAN DRIVER RESPONSE DELAY, SEC
TAURDS	.3700	STANDARD DEVIATION OF DRIVER RESPONSE DELAY, SEC

FIGURE C-6. (continued)

COLLISION DETERMINATION ALGORITHM PARAMETERS

LSVF	7.000	DISTANCE FROM CG TO FRONT OF SUBJECT VEHICLE, FT
LSVR	7.000	DISTANCE FROM CG TO REAR OF SUBJECT VEHICLE, FT
WSV	5.500	WIDTH OF SUBJECT VEHICLE, FT
LOV	14.00	LENGTH OF OBJECT VEHICLE, FT
WOV	5.500	WIDTH OF OBJECT VEHICLE, FT
UHTH	2.000	LONGITUDINAL VELOCITY THRESHOLD USED FOR RUN TERMINATION, FT/SEC
VHTH	2.000	LATERAL VELOCITY THRESHOLD USED FOR RUN TERMINATION, FT/SEC

VISUAL FIXATION CATEGORY DATA

CAT	PCAT	THETAFM	THETAFS	PSIFM	PSIFS	TAUFM	TAUFS
1	0.6830	0.1700	2.1200	-0.2600	2.9200	1.3600	1.6800
2	0.0530	5.0000	0.0	40.0000	0.0	0.7300	0.3300
3	0.0220	-12.0000	0.0	-52.0000	0.0	1.0800	0.7200
4	0.0440	-18.0000	0.0	0.0	0.0	0.6800	0.2700
5	0.0050	-45.0000	0.0	45.0000	0.0	1.4400	0.5000

GLARE SOURCE DATA

NO.	EG	THETAG	PSIG
1	0.0	0.0	0.0
2	0.0	0.0	0.0

LINE-OF-SIGHT PROBABILITIES TO INTERSECTING OR MERGING VEHICLE, PMERG

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.500	0.500	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	0.500	0.250	0.250	0.250	0.500	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

FIGURE C-6. (continued)

LUMINOUS INTENSITY OF SUBJECT VEHICLE HEADLIGHTS, ISV

GAMMAV	ISV
4.00	1000.00
3.00	1000.00
2.00	1000.00
1.00	1300.00
0.0	3000.00
-1.00	11000.00
-2.00	12000.00
-3.00	7900.00
-4.00	4000.00
-5.00	1800.00
-6.00	1000.00

LUMINOUS INTENSITY OF ONCOMING VEHICLE HEADLIGHTS, INV

	GAMMAH										
GAMMAV	-10.00	-9.00	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.0
4.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
3.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
2.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
1.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1300.00
0.0	1900.00	1900.00	1900.00	1900.00	1900.00	1900.00	1900.00	1900.00	1900.00	1900.00	3000.00
-1.00	3500.00	3500.00	3500.00	3500.00	3800.00	3900.00	4050.00	4200.00	5200.00	6500.00	11000.00

FOVEAL THRESHOLD CONTRAST DATA, LOG10(CFOV)

	LOG10(AREA)						
LOG10(LA+LV)	-3.66	-2.66	-1.66	-0.66	0.34	1.34	2.34
-3.00	2.98	2.00	1.27	0.81	0.62	0.46	0.37
-2.00	2.09	1.12	0.37	0.01	-0.20	-0.33	-0.39
-1.00	1.37	0.42	-0.29	-0.68	-0.87	-0.96	-1.03
0.0	0.82	-0.14	-0.78	-1.08	-1.25	-1.34	-1.37
1.00	0.42	-0.49	-0.98	-1.22	-1.34	-1.41	-1.44
2.00	0.11	-0.73	-1.13	-1.30	-1.39	-1.45	-1.47
3.00	-0.03	-0.84	-1.20	-1.35	-1.42	-1.47	-1.49
4.00	-0.10	-0.90	-1.24	-1.38	-1.44	-1.48	-1.50

PERIPHERAL THRESHOLD CONTRAST DATA, LOG10(CPER)

ALPHA	LOG10(AREA) -3.66	-2.66	-1.66	-0.66	0.34	1.34	2.34
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.25	0.21	0.12	0.08	0.05	0.02	0.0
2.00	0.43	0.39	0.21	0.13	0.09	0.05	0.01
3.00	0.56	0.51	0.28	0.19	0.13	0.07	0.02
4.00	0.66	0.61	0.35	0.24	0.17	0.10	0.03
5.00	0.74	0.69	0.41	0.29	0.22	0.14	0.06
6.00	0.81	0.76	0.47	0.34	0.26	0.18	0.09
7.00	0.87	0.81	0.52	0.39	0.30	0.21	0.12
8.00	0.92	0.86	0.58	0.44	0.34	0.25	0.15
9.00	0.97	0.91	0.63	0.48	0.38	0.28	0.18
10.00	1.02	0.97	0.68	0.52	0.42	0.32	0.22
15.00	1.25	1.20	0.91	0.74	0.63	0.51	0.39
20.00	1.49	1.44	1.15	0.97	0.84	0.70	0.56
25.00	1.73	1.68	1.38	1.19	1.04	0.89	0.74
30.00	1.96	1.91	1.61	1.42	1.25	1.08	0.91
35.00	2.20	2.14	1.85	1.63	1.45	1.27	1.09
40.00	2.44	2.37	2.08	1.85	1.66	1.46	1.26
45.00	2.67	2.61	2.32	2.07	1.86	1.65	1.44
50.00	2.91	2.84	2.55	2.30	2.07	1.84	1.61
55.00	3.14	3.08	2.79	2.52	2.27	2.03	1.79
60.00	3.38	3.31	3.02	2.72	2.48	2.22	1.96
65.00	3.62	3.54	3.25	2.96	2.69	2.41	2.13
70.00	3.85	3.78	3.49	3.18	2.89	2.60	2.31
75.00	4.09	4.01	3.72	3.41	3.10	2.79	2.48
80.00	4.32	4.25	3.96	3.63	3.30	2.98	2.66
85.00	4.56	4.48	4.19	3.85	3.51	3.17	2.83
90.00	4.80	4.71	4.42	4.07	3.72	3.36	3.00

FIGURE C-6. (continued)

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TRIAL = 1 UHO = 40.0000 HOV = 35.0000

TIME	1.33																
IC	1	DTCTF	1	X	77.98	THF	-1.85	PSF	-2.53	TAUF	1.90	PLOS	0.0			LA	0.210
XO	35.00	YO	0.0	ZO	-2.00	THO	-3.27	PSO	0.0	ALPHO	2.90	GVO	0.0	ISVO	0.	LO	1413.572
XL	131.37	YL	0.0	ZL	-2.00	THL	-0.87	PSL	0.0	ALPHL	2.71	GVB	0.0	ISVB	0.	LB	40.388
XN	33.93	YN	-12.00	ZN	-2.00	THN	-3.37	PSN	-19.48	ALPHN	17.01			INV	1000.	LV	0.059
AREAO	0.292	CAPPO	******	CFOVO	-0.87	CPERO	0.18	CTHO	0.20	CRELO	******	PDO	1.00	PCO	1.00	PHO	0.0
AREAL	0.021	CAPPL	******	CFOVL	0.0	CPERL	0.26	CTHL	0.60	CRELL	******	PDL	0.20	PCL	1.00	PD	1.00

TIME	1.329	1.829	2.329	2.829	3.329	3.829
DELSW	0.0	0.0	0.0	0.0	0.0	0.0
DELB	0.0	0.404	0.404	0.404	0.404	0.404
UH	40.000	37.727	34.090	30.453	26.816	23.179
VH	0.0	0.0	0.0	0.0	0.0	0.0
WH	0.0	0.120	-0.102	0.059	-0.033	0.020
X	77.978	106.796	133.129	156.795	177.793	196.125
Y	0.0	0.0	0.0	0.0	0.0	0.0
Z	0.0	0.027	0.014	0.030	0.016	0.026
WX	0.0	0.0	0.0	0.0	0.0	0.0
WY	0.0	-2.911	0.297	-0.232	0.246	-0.166
WZ	0.0	0.0	0.0	0.0	0.0	0.0
PHI	0.0	0.0	0.0	0.0	0.0	0.0
THETA	0.0	-1.483	-0.914	-1.170	-1.061	-1.128
PSI	0.0	0.0	0.0	0.0	0.0	0.0
UOV	40.000	36.387	30.898	25.410	19.921	14.432
XOV	112.978	141.439	166.110	186.755	203.376	215.972
ULV	32.705	29.960	27.216	24.472	21.728	18.983
XLV	205.867	228.844	249.808	268.760	285.700	300.627
UNV	40.000	40.000	40.000	40.000	40.000	40.000
XNV	1621.641	1592.308	1562.975	1533.642	1504.309	1474.976
FHX	0.0	-1249.380	-1249.380	-1249.380	-1249.380	-1249.380
FHY	0.0	0.0	0.0	0.0	0.0	0.0
FHZ	0.000	-1.725	65.329	-57.756	37.752	-24.072
THX	0.0	0.0	0.0	0.0	0.0	0.0
THY	0.0	1183.533	-331.252	90.276	-59.603	47.615
THZ	0.0	0.0	0.0	0.0	0.0	0.0
BETA	0.0	0.0	0.0	0.0	0.0	0.0
HEADING	0.0	0.0	0.0	0.0	0.0	0.0
VTOT	58.667	55.333	49.999	44.664	39.330	33.996
VX	58.667	55.333	49.999	44.664	39.330	33.996
VY	0.0	0.0	0.0	0.0	0.0	0.0
ATOT	0.0	10.668	10.668	10.668	10.668	10.668
AX	0.0	-10.668	-10.668	-10.668	-10.668	-10.668
AY	0.0	0.0	0.0	0.0	0.0	0.0

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**********************************************************************************************************

  TRIAL  =      2   UHO    =    40.0000   HOV    =    35.0000

 TIME  1.84
 IC        4  DTCTF     1  X     108.15  THF  -18.00  PSF    0.0   TAUF    0.76  PLOS    0.0                   LA     0.210
 XO    35.00  YO      0.0  ZO     -2.00  THO   -3.27  PSO    0.0   ALPHO  14.73  GVO     0.0   ISVO      0.   LO  1413.572
 XL   134.42  YL      0.0  ZL     -2.00  THL   -0.85  PSL    0.0   ALPHL  17.15  GVB     0.0   ISVB      0.   LB    40.388
 XN   229.73  YN   -12.00  ZN     -2.00  THN   -0.50  PSN   -2.99  ALPHN  17.72                INV    1451.   LV     0.002
 AREAO 0.292  CAPPO******  CFOVO  -0.83  CPERO  0.71  CTHO   0.76  CRELO******  PDO     1.00  PCO     1.00   PHO    0.0
 AREAL 0.020  CAPPL******  CFOVL   0.0   CPERL  1.03  CTHL   4.04  CRELL802.81  PDL     0.20  PCL     1.00   PD     1.00

TIME           1.843      2.343      2.843

DELSW          0.0        0.0        0.0
DELB           0.0        0.383      0.383
UH            40.000     39.267     38.094
VH             0.0        0.0        0.0
WH             0.0        0.039     -0.033
X            108.143    137.315    165.681
Y              0.0        0.0        0.0
Z              0.0        0.009      0.004
WX             0.0        0.0        0.0
WY             0.0       -0.939      0.095
WZ             0.0        0.0        0.0
PHI            0.0        0.0        0.0
THETA          0.0       -0.478     -0.295
PSI            0.0        0.0        0.0
UOV           36.230     30.741     25.253
XOV          142.199    166.755    187.286
ULV           29.882     27.138     24.393
XLV          229.470    250.377    269.271
UNV           40.000     40.000     40.000
XNV          166.115   2850.993   2821.660
FHX            0.0     -402.999   -402.999
FHY            0.0        0.0        0.0
FHZ            0.000     -0.534     20.981
THX            0.0        0.0        0.0
THY            0.0      381.920   -106.920
THZ            0.0        0.0        0.0
BETA           0.0        0.0        0.0
HEADING        0.0        0.0        0.0
VTOT          58.667     57.591     55.871
VX            58.667     57.591     55.871
VY             0.0        0.0        0.0
ATOT           0.0        3.441      3.441
AX             0.0       -3.441     -3.441
AY             0.0        0.0        0.0
```

FIGURE C-6. (continued)

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*****************************************************************************************************************

  TRIAL  =      1    UHO    =    40.0000    HOV    =    70.0000

 TIME  2.27
 IC          1   DTCTF      1   X     133.25  THF     3.04  PSF     0.10  TAUF    3.02  PLOS    0.0                         LA     0.210
 XO     70.00    YO       0.0   ZO     -2.00  THO    -1.64  PSO     0.0   ALPHO   4.67  GVO     0.0    ISVO        0.   LO 1413.572
 XL    160.84    YL       0.0   ZL     -2.00  THL    -0.71  PSL     0.0   ALPHL   3.75  GVB     0.0    ISVB        0.   LB    40.388
 XN    201.38    YN    -12.00   ZN     -2.00  THN    -0.57  PSN    -3.41  ALPHN   5.03                 INV      1388.   LV     0.030
 AREAO 0.073     CAPPO******    CFOVO  -0.66  CPERO   0.33  CTHO    0.46  CRELO******   PDO     1.00   PCO       1.00   PHO    0.0
 AREAL 0.014     CAPPL******    CFOVL   0.0   CPERL   0.38  CTHL    1.10  CRELL******   PDL     0.20   PCL       1.00   PD     1.00
```

TIME	2.271	2.771	3.271	3.771	4.271
DELSW	0.0	0.0	0.0	0.0	0.0
DELB	0.0	0.460	0.460	0.460	0.460
UH	40.000	38.665	36.529	34.392	32.256
VH	0.0	0.0	0.0	0.0	0.0
WH	0.0	0.071	-0.060	0.035	-0.019
X	133.247	162.277	189.848	215.852	240.290
Y	0.0	0.0	0.0	0.0	0.0
Z	0.0	0.016	0.008	0.017	0.010
WX	0.0	0.0	0.0	0.0	0.0
WY	0.0	-1.710	0.173	-0.136	0.144
WZ	0.0	0.0	0.0	0.0	0.0
PHI	0.0	0.0	0.0	0.0	0.0
THETA	0.0	-0.871	-0.537	-0.687	-0.623
PSI	0.0	0.0	0.0	0.0	0.0
UOV	31.534	26.045	20.557	15.068	9.580
XOV	198.458	219.570	236.657	249.720	258.757
ULV	27.534	24.790	22.045	19.301	16.557
XLV	282.483	301.668	318.841	334.001	347.149
UNV	40.000	40.000	40.000	40.000	40.000
XNV	245.142	215.809	1382.359	1353.026	1323.694
FHX	0.0	-733.822	-733.822	-733.822	-733.822
FHY	0.0	0.0	0.0	0.0	0.0
FHZ	0.000	-0.998	38.269	-33.861	22.127
THX	0.0	0.0	0.0	0.0	0.0
THY	0.0	695.329	-194.640	52.891	-34.906
THZ	0.0	0.0	0.0	0.0	0.0
BETA	0.0	0.0	0.0	0.0	0.0
HEADING	0.0	0.0	0.0	0.0	0.0
VTOT	58.667	56.708	53.575	50.442	47.309
VX	58.667	56.708	53.575	50.442	47.309
VY	0.0	0.0	0.0	0.0	0.0
ATOT	0.0	6.266	6.266	6.266	6.266
AX	0.0	-6.266	-6.266	-6.266	-6.266
AY	0.0	0.0	0.0	0.0	0.0

FIGURE C-6 (continued)

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*****************************************************************************************************************

  TRIAL  =      2    UHO    =    40.0000    HOV    =    70.0000

 TIME  3.92
 IC          1  DTCTF      1   X       229.92  THF     3.31  PSF      6.04  TAUF     4.71  PLOS   0.0                   LA     0.210
 XO     64.11   YO     0.0    ZO       -2.00  THO    -1.79  PSO      0.0   ALPHO    7.98  GVO    0.0    ISVO     0.   LO  1413.572
 XL    147.68   YL     0.0    ZL       -2.00  THL    -0.78  PSL      0.0   ALPHL    7.28  GVB    0.0    ISVB     0.   LB    40.388
 XN   2047.52   YN   -12.00   ZN       -2.00  THN    -0.06  PSN     -0.34  ALPHN    7.20                INV   2551.   LV     0.000
 AREAO 0.087    CAPPO******   CFOVO   -0.66   CPERO   0.49  CTHO     0.67  CRELO******  PDO    1.00   PCO    1.00   PHO    0.0
 AREAL 0.016    CAPPL******   CFOVL    0.0    CPERL   0.57  CTHL     1.62  CRELL******  PDL    0.20   PCL    1.00   PD     1.00

TIME             3.919

DELSW            0.0
DELB             0.0
UH              40.000
VH               0.0
WH               0.0
X              229.923
Y                0.0
Z                0.0
WX               0.0
WY               0.0
WZ               0.0
PHI              0.0
THETA            0.0
PSI              0.0
UOV             13.444
XOV            252.812
ULV             18.489
XLV            338.100
UNV             40.000
XNV           2093.924
FHX              0.0
FHY              0.0
FHZ              0.000
THX              0.0
THY              0.0
THZ              0.0
BETA             0.0
HEADING          0.0
VTOT            58.667
VX              58.667
VY               0.0
ATOT             0.0
AX               0.0
AY               0.0
```

FIGURE C-6. (continued)

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  TRIAL  =      1    UHO    =    40.0000    HOV    =   105.0000

 TIME  2.48
 IC          1  DTCTF       1  X      145.45  THF      2.92  PSF     -3.60  TAUF     1.70  PLOS     0.0                      LA      0.210
 XO     105.00  YO        0.0  ZO      -2.00  THO     -1.09  PSO       0.0  ALPHO    5.38  GVO      0.0  ISVO        0.  LO   1413.572
 XL     202.08  YL        0.0  ZL      -2.00  THL     -0.57  PSL       0.0  ALPHL    5.00  GVB      0.0  ISVB        0.  LB     40.388
 XN      -4.06  YN     -12.00  ZN      -2.00  THN   -153.75  PSN   -108.68  ALPHN   75.02                 INV      2551.  LV        0.0
 AREAO  0.032  CAPPO******  CFOVO  -0.51  CPERO     0.41  CTHO      0.80  CRELO******  PDO     1.00  PCO       1.00  PHO       0.0
 AREAL  0.009  CAPPL******  CFOVL    0.0  CPERL     0.52  CTHL      2.22  CRELL******  PDL     0.20  PCL       1.00  PD       1.00
```

TIME	2.479	2.979	3.479	3.979	4.479	4.979	5.479
DELSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DELB	0.0	0.516	0.516	0.516	0.516	0.516	0.516
UH	40.000	36.295	30.367	24.438	18.510	12.582	6.654
VH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WH	0.0	0.196	-0.167	0.096	-0.054	0.032	-0.019
X	145.446	173.940	198.382	218.477	234.225	245.625	252.678
Y	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Z	0.0	0.044	0.022	0.048	0.026	0.042	0.031
WX	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WY	0.0	-4.744	0.488	-0.381	0.401	-0.272	0.156
WZ	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PHI	0.0	0.0	0.0	0.0	0.0	0.0	0.0
THETA	0.0	-2.417	-1.490	-1.907	-1.730	-1.839	-1.761
PSI	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UOV	29.251	23.763	18.274	12.785	7.297	1.808	0.000
XOV	242.727	262.165	277.579	288.967	296.330	299.669	299.887
ULV	26.393	23.648	20.904	18.160	15.415	12.671	9.927
XLV	325.707	344.055	360.390	374.713	387.024	397.323	405.608
UNV	40.000	40.000	40.000	40.000	40.000	40.000	40.000
XNV	810.041	780.708	751.375	722.042	692.710	663.377	634.044
FHX	0.0	-2036.490	-2036.490	-2036.490	-2036.490	-2036.490	-2036.490
FHY	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FHZ	0.000	-2.921	106.914	-94.404	61.734	-39.395	25.853
THX	0.0	0.0	0.0	0.0	0.0	0.0	0.0
THY	0.0	1928.409	-539.606	147.690	-97.567	77.854	-54.153
THZ	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BETA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HEADING	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VTOT	58.667	53.232	44.538	35.843	27.148	18.453	9.759
VX	58.667	53.232	44.538	35.843	27.148	18.453	9.759
VY	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ATOT	0.0	17.389	17.389	17.389	17.389	17.389	17.389
AX	0.0	-17.389	-17.389	-17.389	-17.389	-17.389	-17.389
AY	0.0	0.0	0.0	0.0	0.0	0.0	0.0

FIGURE C-6 (continued)

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TRIAL = 2 UHO = 40.0000 HOV = 105.0000

TIME 0.16 (BLINK)

TIME 1.58

IC	1	DICTF	1	X	92.98	THF	-3.18	PSF	0.06	TAUF	1.47	PLOS	0.0			LA	0.210
XO	105.00	YO	0.0	ZO	-2.00	THO	-1.09	PSO	0.0	ALPHO	2.09	GVO	0.0	ISVO	0.	LO	1413.572
XL	201.79	YL	0.0	ZL	-2.00	THL	-0.57	PSL	0.0	ALPHL	2.62	GVB	0.0	ISVB	0.	LB	40.388
XN	382.11	YN	-12.00	ZN	-2.00	THN	-0.30	PSN	-1.80	ALPHN	3.43			INV	1630.	LV	0.021
AREAO	0.032	CAPPO	******	CFOVO	-0.53	CPERO	0.20	CTHO	0.47	CRELO	******	PDO	1.00	PCO	1.00	PHO	0.0
AREAL	0.009	CAPPL	******	CFOVL	0.0	CPERL	0.34	CTHL	1.38	CRELL	******	PDL	0.20	PCL	1.00	PD	1.00

TIME	1.585	2.085	2.585	3.085	3.585	4.085	4.585	5.085
DELSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DELB	0.0	0.345	0.345	0.345	0.345	0.345	0.345	0.345
UH	40.000	39.337	38.275	37.214	36.152	35.091	34.030	32.968
VH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WH	0.0	0.035	-0.030	0.017	-0.010	0.006	-0.003	0.002
X	92.980	122.162	150.620	178.299	205.200	231.322	256.666	281.230
Y	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Z	0.0	0.008	0.004	0.009	0.005	0.007	0.006	0.007
WX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WY	0.0	-0.350	0.086	-0.067	0.071	-0.048	0.028	-0.016
WZ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PHI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
THETA	0.0	-0.433	-0.267	-0.341	-0.310	-0.329	-0.315	-0.325
PSI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UOV	39.068	33.580	28.091	22.603	17.114	11.626	6.137	0.648
XOV	197.922	224.559	247.171	265.758	280.321	290.858	297.371	299.859
ULV	31.301	28.557	25.813	23.068	20.324	17.580	14.836	12.091
XLV	287.869	309.817	329.752	347.675	363.585	377.483	389.368	399.241
UNV	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000
XNV	393.855	364.522	335.189	305.856	276.524	247.191	1871.328	1841.995
FHX	0.0	-364.600	-364.600	-364.600	-364.600	-364.600	-364.600	-364.600
FHY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FHZ	0.000	-0.482	18.978	-16.303	10.977	-6.994	4.583	-3.035
THX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
THY	0.0	345.535	-96.734	26.234	-17.309	13.844	-9.633	6.254
THZ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BETA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HEADING	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VTOT	58.667	57.694	56.137	54.580	53.024	51.467	49.910	48.353
VX	58.667	57.694	56.137	54.580	53.024	51.467	49.910	48.353
VY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ATOT	0.0	3.113	3.113	3.113	3.113	3.113	3.113	3.113
AX	0.0	-3.113	-3.113	-3.113	-3.113	-3.113	-3.113	-3.113
AY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

FIGURE C-6. (continued)

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TRIAL = 1 UHO = 55.0000 HOV = 35.0000

TIME 1.58								
IC 1	DICTF 1	X 127.08	THF -1.32	PSF 1.14	TAUF 1.49	PLOS 0.0		LA 0.210
XO 35.00	YO 0.0	ZO -2.00	THO -3.27	PSO 0.0	ALPHO 2.26	GVO 0.0	ISVO 0.	LO 1413.572
XL 132.76	YL 0.0	ZL -2.00	THL -0.86	PSL 0.0	ALPHL 1.22	GVB 0.0	ISVB 0.	LB 40.388
XN 213.84	YN -12.00	ZN -2.00	THN -0.54	PSN -3.21	ALPHN 4.42		INV 1418.	LV 0.035
AREAO 0.292	CAPPO******	CFOVO -0.86	CPERO 0.14	CTHO 0.19	CRELO******	PDO 1.00	PCO 1.00	PHO 0.0
AREAL 0.020	CAPPL******	CFOVL 0.0	CPERL 0.14	CTHL 0.48	CRELL******	PDL 0.20	PCL 1.00	PD 1.00

TIME	1.575	2.075	2.575	3.075
DELSW	0.0	0.0	0.0	0.0
DELB	0.0	0.658	0.658	0.658
UH	55.000	53.380	50.789	48.198
VH	0.0	0.0	0.0	0.0
WH	0.0	0.086	-0.073	0.042
X	127.077	167.043	205.238	241.533
Y	0.0	0.0	0.0	0.0
Z	0.0	0.019	0.010	0.021
WX	0.0	0.0	0.0	0.0
WY	0.0	-2.074	0.211	-0.165
WZ	0.0	0.0	0.0	0.0
PHI	0.0	0.0	0.0	0.0
THETA	0.0	-1.057	-0.651	-0.833
PSI	0.0	0.0	0.0	0.0
UOV	54.173	48.684	43.196	37.707
XOV	162.031	199.745	233.434	263.098
ULV	46.354	43.609	40.865	38.121
XLV	252.088	285.074	316.047	345.008
UNV	55.000	55.000	55.000	55.000
XNV	207.239	580.185	539.852	499.519
FHX	0.0	-890.171	-890.171	-890.171
FHY	0.0	0.0	0.0	0.0
FHZ	0.000	-1.208	46.460	-41.099
THX	0.0	0.0	0.0	0.0
THY	0.0	843.408	-236.084	64.209
THZ	0.0	0.0	0.0	0.0
BETA	0.0	0.0	0.0	0.0
HEADING	0.0	0.0	0.0	0.0
VTOT	80.667	78.291	74.491	70.690
VX	80.667	78.291	74.491	70.690
VY	0.0	0.0	0.0	0.0
ATOT	0.0	7.601	7.601	7.601
AX	0.0	-7.601	-7.601	-7.601
AY	0.0	0.0	0.0	0.0

FIGURE C-6. (continued)

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  TRIAL   =    2    UHO    =     55.0000    HOV    =     35.0000

  TIME   1.90
  IC          2  DTCTF       1  X      153.26  THF      5.00  PSF    40.00  TAUF     1.11  PLOS    0.0                     LA      0.210
  XO     35.00  YO        0.0   ZO      -2.00  THO     -3.27  PSO     0.0   ALPHO 40.42   GVO     0.0    ISVO        0.   LO 1413.572
  XL    133.77  YL        0.0   ZL      -2.00  THL     -0.86  PSL     0.0   ALPHL 40.21   GVB     0.0    ISVB        0.   LB     40.388
  XN    310.95  YN      -12.00  ZN      -2.00  THN     -0.37  PSN    -2.21  ALPHN 42.36                  INV      1568.   LV      0.000
  AREAO  0.292  CAPPO******  CFOVO  -0.83  CPERO    1.84  CTHO   10.29  CRELO634.94   PDO     1.00   PCO       1.00   PHO     0.0
  AREAL  0.020  CAPPL******  CFOVL   0.0   CPERL    2.10  CTHL   47.92  CRELL  68.17   PDL     0.20   PCL       1.00   PD      1.00

  TIME           1.900       2.400       2.900       3.400

  DELSW          0.0         0.0         0.0         0.0
  DELB           0.0         0.425       0.425       0.425
  UH            55.000      52.050      47.329      42.608
  VH             0.0         0.0         0.0         0.0
  WH             0.0         0.156      -0.133       0.077
  X            153.260     192.925     229.363     262.340
  Y              0.0         0.0         0.0         0.0
  Z              0.0         0.035       0.018       0.038
  WX             0.0         0.0         0.0         0.0
  WY             0.0        -3.778       0.387      -0.302
  WZ             0.0         0.0         0.0         0.0
  PHI            0.0         0.0         0.0         0.0
  THETA          0.0        -1.925      -1.187      -1.518
  PSI            0.0         0.0         0.0         0.0
  UOV           50.610      45.121      39.633      34.144
  XOV          186.973     222.074     253.150     280.201
  ULV           44.572      41.828      39.083      36.339
  XLV          273.731     305.410     335.077     362.732
  UNV           55.000      55.000      55.000      55.000
  XNV          247.000     206.668     576.833     536.501
  FHX            0.0     -1621.655   -1621.655   -1621.655
  FHY            0.0         0.0         0.0         0.0
  FHZ            0.000      -2.280      84.955     -75.064
  THX            0.0         0.0         0.0         0.0
  THY            0.0      1535.906    -429.832     117.379
  THZ            0.0         0.0         0.0         0.0
  BETA           0.0         0.0         0.0         0.0
  HEADING        0.0         0.0         0.0         0.0
  VTOT          80.667      76.339      69.416      62.492
  VX            80.667      76.339      69.416      62.492
  VY             0.0         0.0         0.0         0.0
  ATOT           0.0        13.847      13.847      13.847
  AX             0.0       -13.847     -13.847     -13.847
  AY             0.0         0.0         0.0         0.0
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FIGURE C-6. (continued)

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  TRIAL  =     1   UHO    =    55.0000   HOV   =    70.0000

 TIME  2.22
 IC          1  DICTF      1  X     178.98  THF     1.43  PSF    0.57  TAUF   2.88  PLOS   0.0                  LA     0.210
 XO     70.00   YO       0.0  ZO     -2.00  THO    -1.64  PSO    0.0   ALPHO  3.12  GVO    0.0   ISVO     0.   LO 1413.572
 XL    161.67   YL       0.0  ZL     -2.00  THL    -0.71  PSL    0.0   ALPHL  2.21  GVB    0.0   ISVB     0.   LB    40.388
 XN    184.26   YN    -12.00  ZN     -2.00  THN    -0.62  PSN   -3.73  ALPHN  4.75               INV   1340.   LV     0.038
 AREAO 0.073    CAPPO******   CFOVO  -0.67  CPERO   0.24  CTHO   0.37  CRELO******  PDO    1.00  PCO    1.00   PHO    0.0
 AREAL 0.014    CAPPL******   CFOVL   0.0   CPERL   0.26  CTHL   0.83  CRELL******  PDL    0.20  PCL    1.00   PD     1.00

TIME            2.217      2.717      3.217      3.717

DELSW           0.0        0.0        0.0        0.0
DEL3            0.0        0.449      0.449      0.449
UH             55.000     54.821     54.535     54.249
VH              0.0        0.0        0.0        0.0
WH              0.0        0.009     -0.008      0.005
X             178.876    219.168    259.265    299.150
Y               0.0        0.0        0.0        0.0
Z               0.0        0.002      0.001      0.002
WX              0.0        0.0        0.0        0.0
WY              0.0       -0.229      0.023     -0.018
WZ              0.0        0.0        0.0        0.0
PHI             0.0        0.0        0.0        0.0
THETA           0.0       -0.117     -0.072     -0.092
PSI             0.0        0.0        0.0        0.0
UOV            47.124     41.636     36.147     30.659
XOV           244.732    277.276    305.796    330.291
ULV            42.829     40.085     37.341     34.596
XLV           329.084    359.485    387.874    414.250
UNV            55.000     55.000     55.000     55.000
XNV           237.524    753.157    712.824    672.492
FHX             0.0      -98.279    -98.279    -98.279
FHY             0.0        0.0        0.0        0.0
FHZ             0.000     -0.128      5.108     -4.525
THX             0.0        0.0        0.0        0.0
THY             0.0       93.153    -26.085      7.063
THZ             0.0        0.0        0.0        0.0
BETA            0.0        0.0        0.0        0.0
HEADING         0.0        0.0        0.0        0.0
VTOT           80.667     80.404     79.985     79.565
VX             80.667     80.404     79.985     79.565
VY              0.0        0.0        0.0        0.0
ATOT            0.0        0.839      0.839      0.839
AX              0.0       -0.839     -0.839     -0.839
AY              0.0        0.0        0.0        0.0
```

FIGURE C-6. (continued)

```
TRIAL  =     2   UHO    =    55.0000    HOV   =    70.0000

TIME  0.16  (BLINK)

TIME  0.32  (BLINK)

TIME  1.50
IC         1  DTCTF     1   X      121.25  THF     5.04  PSF    -4.54  TAUF    1.42  PLOS   0.0                  LA    0.210
XO     70.00  YO      0.0   ZO      -2.00  THO    -1.64  PSO     0.0   ALPHO   8.05  GVO    0.0   ISVO      0.  LO 1413.572
XL    165.73  YL      0.0   ZL      -2.00  THL    -0.69  PSL     0.0   ALPHL   7.29  GVB    0.0   ISVB      0.  LB   40.388
XN     63.79  YN   -12.00   ZN      -2.00  THN    -1.80  PSN   -10.65  ALPHN   9.13               INV    1000.  LV    0.063
AREAO 0.073   CAPPO******   CFOVO   -0.69  CPERO   0.51  CTHO    0.66  CRELO******  PDO    1.00   PCO     1.00  PHO   0.0
AREAL 0.013   CAPPL******   CFOVL    0.0   CPERL   0.60  CTHL    1.79  CRELL******  PDL    0.20   PCL     1.00  PD    1.00
```

TIME	1.503	2.003	2.503	3.003	3.503	4.003	4.503	5.003	5.503	6.003
DELSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DELB	0.0	0.596	0.596	0.596	0.596	0.596	0.596	0.596	0.596	0.596
UH	55.000	51.495	45.849	40.197	34.545	28.893	23.241	17.589	11.937	6.286
VH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WH	0.0	0.186	-0.155	0.089	-0.050	0.030	-0.018	0.011	-0.006	0.004
X	121.253	160.788	196.483	228.033	255.438	278.696	297.810	312.778	323.602	330.281
Y	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Z	0.0	0.041	0.021	0.046	0.025	0.040	0.030	0.037	0.032	0.035
WX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WY	0.0	-4.310	0.441	-0.362	0.375	-0.252	0.145	-0.081	0.046	-0.026
WZ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PHI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
THETA	0.0	-2.293	-1.431	-1.814	-1.650	-1.753	-1.679	-1.730	-1.696	-1.719
PSI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UOV	54.965	49.477	43.988	38.500	33.011	27.523	22.034	16.546	11.057	5.569
XOV	191.253	229.548	263.818	294.063	320.284	342.479	360.650	374.796	384.917	391.012
ULV	46.750	44.006	41.261	38.517	35.773	33.028	30.284	27.540	24.796	22.051
XLV	282.159	315.436	346.699	375.951	403.190	428.417	451.631	472.833	492.022	509.199
UNV	55.000	55.000	55.000	55.000	55.000P	55.000	55.000	55.000	55.000	55.000
XNV	1834.187	1793.854	1753.522	1713.189	1672.856	1632.524	1592.191	1551.858	1511.526	1471.193
FHX	0.0	-1903.314	-1941.540	-1941.540	-1941.540	-1941.540	-1941.540	-1941.540	-1941.540	-1941.540
FHY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FHZ	0.000	-6.095	101.140	-88.039	57.430	-36.669	24.076	-15.953	10.522	-6.897
THX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
THY	0.0	1858.443	-489.851	136.220	-91.394	72.712	-50.437	32.747	-21.077	13.618
THZ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BETA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HEADING	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VTOT	80.667	75.526	67.245	58.956	50.666	42.377	34.087	25.798	17.508	9.219
VX	80.667	75.526	67.245	58.956	50.666	42.377	34.087	25.798	17.508	9.219
VY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ATOT	0.0	16.252	16.579	16.579	16.579	16.579	16.579	16.579	16.579	16.579
AX	0.0	-16.252	-16.579	-16.579	-16.579	-16.579	-16.579	-16.579	-16.579	-16.579
AY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

FIGURE C-6. (continued)

TIME	1.503
DELSW	0.0
DEL3	0.0
UH	55.000
VH	0.0
WH	0.0
X	121.253
Y	0.0
Z	0.0
WX	0.0
WY	0.0
WZ	0.0
PHI	0.0
THETA	0.0
PSI	0.0
UOV	54.965
XOV	191.253
ULV	46.750
XLV	282.159
UNV	55.000
XNV	1834.187
FHX	0.0
FHY	0.0
FHZ	0.000
THX	0.0
THY	0.0
THZ	0.0
BETA	0.0
HEADING	0.0
VTOT	80.667
VX	80.667
VY	0.0
ATOT	0.0
AX	0.0
AY	0.0

FIGURE C-[illegible] (continued)

```
*************************************************************************************************************************

 TRIAL  =     1    UHO    =    55.0000    HOV    =    105.0000

TIME  0.16  (BLINK)

TIME   0.99
IC          1  DTCTF      1  X      79.68  THF     3.58  PSF    -4.52  TAUF    0.40  PLOS   0.0              LA     0.210
XO     105.00  YO       0.0  ZO     -2.00  THO    -1.09  PSO     0.0   ALPHO   6.49  GVO    0.0  ISVO     0.  LO  1413.572
XL     204.49  YL       0.0  ZL     -2.00  THL    -0.56  PSL     0.0   ALPHL   6.12  GVB    0.0  ISVB     0.  LB    40.388
XN      42.60  YN    -12.00  ZN     -2.00  THN    -2.69  PSN   -15.73  ALPHN  12.77             INV   1000.  LV     0.069
AREAO 0.032    CAPPO******   CFOVO  -0.57  CPERO   0.47  CTHO    0.80  CRELO******  PDO    1.00  PCO    1.00  PHO    0.0
AREAL 0.009    CAPPL******   CFOVL   0.0   CPERL   0.59  CTHL    2.31  CRELL******  PDL    0.20  PCL    1.00  PD     1.00
```

TIME	0.989	1.488	1.988	2.488	2.988	3.488	3.998	4.488	4.988	5.488
DELSW	0.0	-89.283	86.771	-30.470	7.208	3.050	2.903	3.087	2.547	2.199
DELB	0.0	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270
UH	55.000	53.860	51.827	50.226	48.492	46.763	45.033	43.304	41.576	39.849
VH	0.0	0.432	4.344	0.439	-0.343	-0.424	-0.527	-0.488	-0.434	-0.358
WH	0.0	0.062	-0.063	0.038	-0.023	0.014	-0.008	0.005	-0.003	0.002
X	79.683	119.764	158.556	195.992	232.117	266.985	300.601	332.962	364.068	393.915
Y	0.0	-0.103	-1.250	-3.108	-5.360	-7.384	-9.083	-10.433	-11.444	-12.153
Z	0.0	0.013	0.006	0.015	0.007	0.013	0.009	0.011	0.010	0.011
WX	0.0	0.200	-5.205	0.274	-0.924	-0.066	-0.118	0.074	0.105	0.137
WY	0.0	-2.046	0.286	-0.050	0.207	-0.119	0.055	-0.046	.016	-0.018
WZ	0.0	-10.387	-2.568	6.159	0.087	1.496	1.025	1.001	0.864	0.724
PHI	0.0	1.906	1.195	1.331	-0.491	-0.374	-0.480	-0.480	-0.439	-0.382
THETA	0.0	-0.739	-0.402	-0.566	-0.496	-0.540	-0.509	-0.530	-0.516	-0.525
PSI	0.0	-1.173	-7.229	-3.841	-3.132	-2.593	-1.980	-1.475	-1.005	-0.609
UOV	55.000	55.000	49.645	44.157	38.668	33.180	27.691	22.203	16.714	11.226
XOV	184.683	225.015	263.433	297.826	328.195	354.539	376.858	395.152	409.421	419.666
ULV	49.578	46.834	44.090	41.345	38.601	35.857	33.113	30.368	27.624	24.880
XLV	280.755	316.106	349.444	380.770	410.083	437.384	462.673	485.948	507.212	526.463
UNV	55.000	55.000	55.000	55.000	55.000	55.000	55.000	55.000	55.000	55.000
XNV	2379.623	2339.291	2298.958	2258.625	2218.292	2177.960	2137.627	2097.295	2056.962	2016.629
FHX	0.0	-658.260	-604.187	-603.566	-592.866	-592.318	-592.365	-592.383	-592.302	-592.242
FHY	0.0	-661.978	-317.671	-303.332	121.014	119.906	145.939	144.361	131.369	113.628
FHZ	0.000	5.871	32.035	-33.696	21.829	-14.764	9.975	-6.635	4.378	-2.877
THX	0.0	-155.312	88.478	-209.060	88.140	-10.059	4.074	0.540	0.399	0.456
THY	0.0	562.559	-270.175	45.470	-49.574	32.901	-20.781	13.484	-8.876	5.751
THZ	0.0	-1946.983	2757.347	-1233.503	184.812	-28.848	-11.709	-5.778	-13.053	-11.598
BETA	0.0	0.460	4.792	0.500	-0.406	-0.520	-0.671	-0.646	-0.598	-0.515
HEADING	0.0	-0.713	-2.437	-3.341	-3.538	-3.113	-2.651	-2.121	-1.603	-1.123
VTOT	80.667	78.997	76.279	73.668	71.123	68.588	66.053	63.517	60.982	58.448
VX	80.667	78.991	76.211	73.543	70.988	68.487	65.983	63.473	60.958	58.437
VY	0.0	-0.983	-3.243	-4.293	-4.389	-3.724	-3.055	-2.351	-1.706	-1.146
ATOT	0.0	7.971	5.829	5.768	5.167	5.160	5.209	5.206	5.180	5.149
AX	0.0	-5.735	-5.459	-5.316	-4.998	-5.006	-5.012	-5.025	-5.037	-5.046
AY	0.0	-5.536	-2.042	-2.239	1.308	1.252	1.421	1.362	1.210	1.024

FIGURE C-6. (continued)

TIME	5.988
DELSW	1.709
DELR	0.270
UH	38.123
VH	-0.279
WH	-0.001
X	422.499
Y	-12.607
Z	0.010
WX	0.149
WY	0.004
WZ	0.574
PHI	-0.312
THETA	-0.519
PSI	-0.283
UOV	5.737
XOV	425.885
ULV	22.136
XLV	543.702
UNV	55.000
XNV	1976.297
FHX	-592.176
FHY	92.308
FHZ	1.885
THX	0.068
THY	-3.762
THZ	-12.903
BETA	-0.420
HEADING	-0.703
VTOT	55.916
VX	55.912
VY	-0.327
ATOT	5.118
AX	-5.053
AY	0.813

FIGURE C-6. (continued)

```
*****************************************************************************************************
 TRIAL  =      2    UHO    =      55.0000    HOV    =   105.0000

 TIME  3.96
 IC          1  DTCTF        1  X      319.05  THF    -0.09  PSF    -5.42  TAUF    3.69  PLOS    0.0                    LA     0.210
 XO     104.04  YO        0.0   ZO      -2.00  THO    -1.10  PSO     0.0   ALPHO   5.51  GVO     0.0   ISVO       0.    LO  1413.572
 XL     101.29  YL        0.0   ZL      -2.00  THL    -0.60  PSL     0.0   ALPHL   5.44  GVB     0.0   ISVB       0.    LB    40.388
 XN     132.32  YN      -12.00  ZN      -2.00  THN    -0.87  PSN    -5.18  ALPHN   0.81                INV     1121.    LV     2.129
 AREAO 0.033  CAPPO587.03  CFOVO -0.99  CPERO  0.42  CTHO   0.33  CRELO******  PDO     1.00  PCO     1.00  PHO    0.0
 AREAL 0.010  CAPPL293.51  CFOVL  0.0   CPERL  0.54  CTHL   0.77  CRELL330.70  PDL     0.20  PCL     1.00  PD     1.00

 TIME            3.955        4.455

 DELSW           0.0          0.0
 DELB            0.0          0.234
 UH             55.000       54.415
 VH              0.0          0.0
 WH              0.0          0.031
 X             319.052      359.251
 Y               0.0          0.0
 Z               0.0          0.007
 WX              0.0          0.0
 WY              0.0         -0.749
 WZ              0.0          0.0
 PHI             0.0          0.0
 THETA           0.0        P-0.382
 PSI             0.0          0.0
 UOV            23.049       22.560
 XOV           375.527      394.083
 ULV            33.291       30.547
 XLV           461.086      484.494
 UNV            55.000       55.000
 XNV           834.980      794.648
 FHX             0.0       -321.396
 FHY             0.0          0.0
 FHZ             0.000       -0.424
 THX             0.0          0.0
 THY             0.0        304.603
 THZ             0.0          0.0
 BETA            0.0          0.0
 HEADING         0.0          0.0
 VTOT           80.667       79.809
 VX             80.667       79.809
 VY              0.0          0.0
 ATOT            0.0          2.744
 AX              0.0         -2.744
 AY              0.0          0.0

*****************************************************************************************************
R: T=1.16/7.00 16:14:22

C>
```

FIGURE C-6. (concluded)

APPENDIX D

VEHICLE MODEL EQUATIONS

This appendix represents detailed equations for each of the four vehicle models discussed in Section 6. Before presenting the model equations, we discuss one aspect common to three of the models which requires special handling.

LATERAL-AXIS RESPONSE CHARACTERISTICS

The 2, 3, and 6 DOF models include the coupled yaw-rate/lateral-velocity modes which describe lateral (or steering) response characteristics of the automobile. The linearized 2 DOF model* (on which our 2 DOF model is based) points up a rather peculiar characteristic of automobile lateral-axis models: yaw-rate response speed is inversely proportional to vehicle velocity.† Thus as vehicle velocity approaches zero, yaw-rate response becomes infinitely fast.

This presents a problem for simulation of such vehicles when forward velocity approaches zero. For vehicles with neutral steering characteristics (see reference), this yaw-rate response has a frequency (or inverse time constant) of

$$1/T_r = gC_{sr}/u_{h_0} \qquad \text{(D-1)}$$

where u_{h_0} = forward velocity, ft/sec

C_{sr} = cornering stiffness of rear tires, lb/lb-rad

g = gravity (32.2 ft/sec^2)

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*D. T. McRuer and R.H. Klein, "Automobile Controllability/Driver-Vehicle Response for Steering Control: Volume I--Summary Report," Report no. DOT-HS-801-407, Systems Technology, Inc., Hawthorne, California, February 1975.

† Actually this same phenomenon occurs with aircraft models, but in this case forward velocity never becomes very small (except for helicopters and STOL aircraft).

For a typical standard-size sedan with $C_{sr} \cong 5$, traveling at 55 mph (~80 ft/sec), we have

$$1/T_r \simeq (32)(5)/80 = 2 \text{ rad/sec}$$

For non-neutral steering, yaw-rate/lateral-velocity dynamics have a complex pair of eigenvalues with frequency as large as two or three times this value (that is, ~ 5 rad/sec). Suspension system characteristics should contain frequencies no higher than about 10 rad/sec. Thus, with a second order Adams-Bashford integration algorithm, a step size of $\Delta t = 0.05$ sec should be adequate at 55 mph. In fact, this step size may well be adequate for speeds as low as 11 mph (~ 16 ft/sec) since lateral-axis response frequency approaches $1/T_r$ as velocity goes to zero even for non-neutral steering characteristics.

For the 3 and 6 DOF models under combined steering and braking maneuvers, the problem is more complicated. In order to simulate the vehicle as forward velocity goes to zero, we must decrease step size as a function of this velocity. For example, each time velocity is halved, step size must also be halved. If one were to carry this to the limit, an infinite number of iterations would be required to simulate a finite amount of time no matter what the initial step size. Clearly, there reaches a point where we must be willing to eliminate these high-frequency dynamics and use a steady-state approximation.

Assuming a constant integration step size and that the 2 DOF model linearized dynamic are valid, we can compute a threshold forward velocity (u_{th}) below which steady-state dynamics must be substituted for actual dynamics. Using Equation (D-1) and solving for the velocity, at which $T_r = 2\Delta t$ (to insure integration stability), gives

$$u_{th} = 2gC_{sr}\Delta t$$

For the typical vehicle described above and using an integration step size of $\Delta t = 0.05$ sec, we have

$$u_{th} \simeq 2(32)(5)(0.05) = 16 \text{ ft/sec } (\sim 11 \text{ mph})$$

which is still a significant velocity. Cutting integration step size to 0.025 sec would reduce this threshold to 8 ft/sec (~ 5 mph), which is a little more attractive. Moreover it provides a little more margin for stability of suspension system dynamics. In this case steady-state dynamics would be used below 5 mph, which should be adequate for most applications.

For the 3 and 6 DOF models, a similar threshold is needed for lateral velocity (v_{th}) since lateral tire forces for a slowly-moving (or nearly stopped) vehicle cause lateral velocity to chatter. This is due to the way in which lateral tire forces are modelled at very slow speeds; that is,

$$\dot{v}_h \cong g\,SNR\,\bar{\mu}\,\mathrm{sgn}\,(v_h)$$

where

$$\bar{\mu} = (\mu_{yf}d_r + \mu_{yr}d_f)/(d_f + d_r)$$

is a weighted average lateral coefficient of friction for the vehicle and sgn ($\cdot$) is the signum function, with parameters defined in Section 11. For a fixed integration step size, this produces a chatter (or bang-bang response) in lateral velocity with magnitude

$$v_h = gSNR\,\bar{\mu}\,\Delta t$$

For safety, we choose a lateral velocity threshold of twice this, or

$$v_{th} = 2g\Delta t\,SNR\,(\mu_{yf}d_r + \mu_{yr}d_f)/(d_f + d_r)$$

below which steady-state lateral velocity computations are used. Typical values for this threshold when $SNR = \mu_{yf} = \mu_{yr} \cong 1$ and $\Delta t = 0.025$ sec are

$$v_{th} \cong 2(32)\,(0.025)\,(1)\,(1) = 1.6 \text{ ft/sec } (\sim 1 \text{ mph})$$

which again should be adequate for most applications.

VEHICLE MODEL EQUATIONS

Model equations are presented for each of the four vehicle models discussed in Section 11 in each of the next four subsections. A sketch of the vehicle indicating coordinate systems used and critical vehicle parameters was presented in Section 11. State descriptions with associated control inputs were also discussed at length, as were input parameters and initial conditions. Flow charts and FORTRAN listings for each of the models appear in Appendixes A and B, respectively. A description of intermediate variables and constants common to all of the models appears in Table D-1. Supplementary intermediate variable calculations performed outside of the vehicle models are summarized in Table D-2. These calculations are not needed in the vehicle models and are performed in the MAIN program primarily for the purpose of detailed time-history output.

SIX-DEGREE-OF-FREEDOM (6 DOF) MODEL

Steering and Braking Control Inputs and (Optional) Speed Control Feedback

$$\delta_w = K_{sw} \, \delta_{sw} / 57.3$$

$$F_{bi} = K_{bf} \, \delta_{bp} / h_f \qquad i = 1, 2$$

$$= K_{br} \, \delta_{bp} / h_r \qquad i = 3, 4$$

$$F_t = \tfrac{1}{2} \min \{ -K_{sc} (u_h - u_{cmd}), \; T_d \max \} / h_r \qquad \delta_b = 0$$

$$= 0 \qquad \delta_b = 0$$

where

$$\delta_{bp} = \delta_b \, \delta_{bp_{max}}$$

with

$$F_{bf_{max}} = \tfrac{1}{2} W \, SNR \, \mu_{xf} \, \frac{d_r + SNR \, \mu_{xr} \, h_{cg}}{d_f + d_r + h_{cg} \, SNR(\mu_{xr} - \mu_{xf})}$$

$$F_{br_{max}} = \tfrac{1}{2} W \, SNR \, \mu_{xr} \, \frac{d_f - SNR \, \mu_{xf} \, hcg}{d_f + d_r + h_{cg} \, SNR(\mu_{xr} - \mu_{xf})}$$

$$\delta_{bp_{max}} = \max \{ F_{bf_{max}} \, h_f / K_{bf}, \; F_{br_{max}} \, hr / K_{br} \}$$

TABLE D-1. INTERMEDIATE VARIABLES AND CONSTANTS FOR VEHICLE SIMULATION

Variable	Description
F_{hx}	Total applied forces along x horizontal body axis (+ forward), lb
F_{hy}	Total applied forces along y horizontal body axis (+ right), lb
F_{hz}	Total applied forces along z horizontal body axis (+ down), lb
T_{hx}	Total applied torques about x horizontal body axis (+ clockwise), ft-lb
T_{hy}	Total applied torques about y horizontal body axis (+ clockwise), ft-lb
T_{hz}	Total applied torques about z horizontal body axis (+ clockwise), ft-lb
β	Vehicle sideslip (+ clockwise), deg
ψ_{head}	Vehicle heading (direction of travel, + clockwise), deg
V_{tot}	Total velocity of vehicle CG, ft/sec
V_x	Inertial x velocity of vehicle CG (+ forward), ft/sec
V_y	Inertial y velocity of vehicle CG (+ right), ft/sec
a_{tot}	Total acceleration of vehicle CG, ft/sec^2
a_x	Inertial x acceleration of vehicle CG (+ forward), ft/sec^2
a_y	Inertial y acceleration of vehicle CG (+ right), ft/sec^2
M	Total vehicle mass (= W/g), slugs
h_{cg}	Effective height of vehicle CG, ft
$F_{bf_{max}}$	Maximum braking force that each front wheel can sustain, lb
$F_{br_{max}}$	Maximum braking force that each rear wheel can sustain, lb
F_t	Drive force applied to each rear wheel for speed control, lb
$\delta_{bf_{th}}$	Brake pedal force needed to lock front wheels, lb
$\delta_{br_{th}}$	Brake pedal force needed to lock rear wheels, lb
δ_{bp}	Applied brake pedal force, lb
$\delta_{bp_{min}}$	Brake pedal force needed to lock either front or rear wheels (whichever occurs first), lb
$\delta_{bp_{max}}$	Maximum effective brake pedal force (pedal force needed to lock all wheels), lb
δ_w	Front wheel steer angle, rad
F_{bi}	Available braking force magnitude at ith wheel, lb
F_{ni}	Normal force at ith wheel (+ up), lb
F_{cmi}	Maximum circumferential force magnitude that ith wheel can sustain, lb (determined from friction ellipse)
F_{ci}	Applied circumferential force at ith wheel due to braking or drive forces (opposes braking force, + forward)
F_{smi}	Maximum side force magnitude that ith wheel can sustain, lb (determined from friction ellipse)
F_{si}	Applied side force at ith wheel due to tire sideslip (+ right), lb
F_{xi}	Applied force at ith wheel along x horizontal body axis (+ forward), lb
F_{yi}	Applied force at ith wheel along y horizontal body axis (+ right), lb
u_i	Velocity of ith wheel contact point wrt CG along x body axis, ft/sec
v_i	Velocity of ith wheel contact point wrt CG along y body axis, ft/sec
w_i	Velocity of ith wheel contact point wrt CG along z body axis, ft/sec
u_{hi}	Total velocity of ith wheel contact point along x horizontal body axis, ft/sec
v_{hi}	Total velocity o ith wheel contact point along y horizontal body axis, ft/sec
w_{hi}	Suspension system deflection rates at ith wheel along z horizontal body axis, ft/sec
z_i	Suspension system deflection at ith wheel along z horizontal body axis, ft
β_i	Sideslip angle for ith wheel (+ clockwise), rad
$\bar{\beta}_i$	Normalized sideslip angle at ith wheel, rad/rad

TABLE D-2. SUPPLEMENTARY VEHICLE CALCULATIONS PERFORMED IN MAIN PROGRAM

<u>Vehicle Velocities in Inertial Coordinates (ft/sec):</u>

$$V_x = u_h \cos \psi - v_h \sin \psi = \dot{x}$$

$$V_y = u_h \sin \psi + v_h \cos \psi = \dot{y}$$

$$V_{tot} = [V_x^2 + V_y^2]^{1/2}$$

<u>Vehicle Acceleration in Inertial Coordinates (ft/sec²):</u>

$$a_x = (F_{hx} \cos \psi - F_{hy} \sin \psi)/M$$

$$a_y = (F_{hx} \sin \psi + F_{hy} \cos \psi)/M$$

$$a_{tot} = [a_x^2 + a_y^2]^{1/2}$$

<u>Vehicle Sideslip and Heading (deg):</u>

$$\beta = 57.3 \tan^{-1}(v_h/u_h)$$

$$\psi_{head} = 57.3\ \psi + \beta \quad [\triangleq 57.3 \tan^{-1}(V_y/V_x)]$$

Wheel Contact Point Velocities in Horizontal Body Coordinates

$$u_{hi} = u_h + u_i + \theta w_i \qquad i = 1, 2, 3, 4$$

$$v_{hi} = v_h + v_i + \phi w_i$$

where

$$u_1 = -\omega_z t_f + \omega_y z_f$$

$$u_2 = \omega_z t_f + \omega_y z_f$$

$$u_3 = -\omega_z t_r + \omega_y z_r$$

$$u_4 = \omega_z t_r + \omega_y z_r$$

$$v_2 = v_1 = \omega_z d_f - \omega_x h_{cg}$$

$$v_4 = v_3 = -\omega_z d_r - \omega_x h_{cg}$$

$$w_1 = \omega_x t_f - \omega_y d_f$$

$$w_2 = -\omega_x t_f - \omega_y d_f$$

$$w_3 = \omega_x t_r + \omega_y d_r$$

$$w_4 = -\omega_x t_r + \omega_y d_r$$

with

$$h_{cg} = [(z_f + h_f) d_f + (z_r + h_r) d_r] / (d_f + d_r)$$

Suspension System Deflection Rates and Positions in Horizontal Body Coordinates

$$w_{hi} = w_h + w_i - \theta u_i + \phi v_i \qquad i = 1, 2, 3, 4$$

$$z_1 = z + \phi t_f - \theta d_f$$

$$z_2 = z - \phi t_f - \theta d_f$$

$$z_3 = z + \phi t_r + \theta d_r$$

$$z_4 = z - \phi t_r + \theta d_r$$

Tire and Suspension Forces in Wheel Coordinates

$$F_{ni} = W_i + K_i z_i + C_i w_{h_i} \qquad i = 1, 2, 3, 4$$

$$F_{ci} = -\min\{F_{bi}, F_{cmi}\} \operatorname{sgn}(u_{hi}) \qquad i = 1, 2$$

$$= -\min\{F_{bi}, F_{cmi}\} \operatorname{sgn}(u_{hi}) + \min\{F_t, \mu_{xi} F_{ni}\} \qquad i = 3, 4$$

$$F_{si} = -\min\{|\tfrac{1}{2} \mu_{yi} \bar{\beta}_i (3 - \bar{\beta}_i^2) F_{ni} + F_{bi} \tan\beta_i|, F_{smi}\} \operatorname{sgn}(\beta_i) \qquad i = 1, 2, 3,$$

where

$$F_{cmi} = \frac{\mu_{yi} F_{ni}}{[(\mu_{yi}/\mu_{xi})^2 + \tan^2 \beta_i]^{\frac{1}{2}}} \qquad i = 1, 2, 3, 4$$

$$F_{smi} = [(\mu_{yi} F_{ni})^2 - (\mu_{yi}/\mu_{xi})^2 F_{ci}^2]^{\frac{1}{2}} \qquad i = 1, 2, 3, 4$$

$$\beta_i = \tan^{-1}\{v_{hi}/|u_{hi}|\} - \delta_w \operatorname{sgn}(u_{hi}) \qquad i = 1, 2$$

$$= \tan^{-1}\{v_{hi}/|u_{hi}|\} \qquad i = 3, 4$$

$$\bar{\beta}_i = \min\{|\beta_i|/\beta_{si}, 1\} \operatorname{sgn}(\beta_i) \qquad i = 1, 2, 3, 4$$

with

$$\left.\begin{aligned} W_i &= \tfrac{1}{2} W \frac{d_r}{d_f + d_r} \\ K_i &= K_f \\ C_i &= C_f \\ \mu_{xi} &= SNR\, \mu_{xf} \\ \mu_{yi} &= SNR\, \mu_{yf} \\ \beta_{si} &= \beta_{sf}/57.3 \end{aligned}\right\} i = 1, 2 \qquad \left.\begin{aligned} W_i &= \tfrac{1}{2} W \frac{d_r}{d_f + d_r} \\ K_i &= K_r \\ C_i &= C_r \\ \mu_{xi} &= SNR\, \mu_{xr} \\ \mu_{yi} &= SNR\, \mu_{yr} \\ \beta_{si} &= \beta_{sr}/57.3 \end{aligned}\right\} i = 3, 4$$

Total Applied Forces and Moments in Horizontal Coordinates

$$F_{hx} = F_{x1} + F_{x2} + F_{x3} + F_{x4}$$

$$F_{hy} = F_{y1} + F_{y2} + F_{y3} + F_{y4}$$

$$F_{hz} = -(F_{n1} + F_{n2} + F_{n3} + F_{n4}) + W$$

$$T_{hx} = t_f (F_{n2} - F_{n1}) + t_r (F_{n4} - F_{n3}) - h_{cg} F_{hy}$$

$$T_{hy} = d_f (F_{n1} + F_{n2}) - d_r (F_{n3} + F_{n4}) + h_{cg} F_{hx}$$

$$T_{hz} = t_f (F_{x2} - F_{x1}) + t_r (F_{x4} - F_{x3}) + d_f (F_{y1} + F_{y2}) - d_r (F_{y3} + F_{y4})$$

where

$$F_{x1} = F_{c1} \cos \delta_w - F_{s1} \sin \delta_w$$

$$F_{x2} = F_{c2} \cos \delta_w - F_{s2} \sin \delta_w$$

$$F_{x3} = F_{c3}$$

$$F_{x4} = F_{c4}$$

$$F_{y1} = F_{c1} \sin \delta_w + F_{s1} \cos \delta_w$$

$$F_{y2} = F_{c2} \sin \delta_w + F_{s2} \cos \delta_w$$

$$F_{y3} = F_{s3}$$

$$F_{y4} = F_{s4}$$

State Derivatives for Velocities Above Threshold ($|u_h| > u_{th}$, or $|v_h| > v_{th}$)

- Linear Velocity in Horizontal Body Coordinates:

$$\dot{u}_h = \dot{\psi} v_h + F_{hx}/M$$

$$\dot{v}_h = - \dot{\psi} u_h + F_{hy}/M$$

$$\dot{w}_h = F_{hz}/M$$

where

$$M = W/g$$

- Linear Position in Inertial Coordinates:

$$\dot{x} = u_h \cos \psi - v_h \sin \psi$$

$$\dot{y} = u_h \sin \psi + v_h \cos \psi$$

$$\dot{z} = w_h$$

- Angular Rates about Body Axes:

$$\dot{\omega}_x = [(I_{yy} - I_{zz})\ \omega_y \omega_z + T_{hx} - \theta\ T_{hz}]/\ I_{xx}$$

$$\dot{\omega}_y = [(I_{zz} - I_{xx})\ \omega_z \omega_x + T_{hy} + \phi\ T_{hz}]/\ I_{yy}$$

$$\dot{\omega}_z = [(I_{xx} - I_{yy})\ \omega_x \omega_y + T_{hz} + \theta\ T_{hx} - \phi\ T_{hy}]/\ I_{zz}$$

- Attitude in Inertial Coordinates:

$$\dot{\phi} = \omega_x + \omega_z\ \theta$$

$$\dot{\theta} = \omega_y - \omega_z\ \phi$$

$$\dot{\psi} = \omega_z + \omega_y\ \phi$$

State Derivatives for Velocities Below Threshold ($|u_h| \leq u_{th},\ |v_h| \leq v_{th}$)

$$\dot{\omega}_x = 0, \quad \omega_x = -\omega_z\ \theta$$

$$\dot{\omega}_y = [(I_{zz} - I_{xx})\ \omega_z \omega_y + T_{hy}]/\ I_{yy}$$

$$\dot{\omega}_z = 0, \quad \omega_z = u_h\ \delta_w/(d_f + d_r)(1 + K_{stab}\ u_h^2)$$

$$\dot{\phi} = 0, \quad \phi = 0$$

$$\dot{\theta} = \omega_y$$

$$\dot{\psi} = \omega_z$$

$$\dot{u}_h = \dot{\psi}\ v_h + F_{hx}/M$$

$$\dot{v}_h = 0, \ v_h = (1 - u_h/gC_{sr})\ d_r\ \omega_z$$

$$\dot{w}_h = F_{hz}/M$$

$$\dot{x} = u_h \cos\psi - v_h \sin\psi$$

$$\dot{y} = u_h \sin\psi + v_h \cos\psi$$

$$\dot{z} = w_h$$

with

$$C_{sf} = \frac{3}{2}\,(57.3)\,SNR\,\mu_{yf} / \beta_{sf}$$

$$C_{sr} = \frac{3}{2}\,(57.3)\,SNR\,\mu_{yr} / \beta_{sr}$$

$$K_{stab} = (1/C_{sf} - 1/C_{sr}) / g\,(d_f + d_r)$$

$$u_{th} = 2g\,C_{sr}\,\Delta t$$

$$v_{th} = 2g\,SNR\,\Delta t\,(\mu_{yf} d_r + \mu_{yr} d_f)/(d_f + d_r)$$

THREE-DEGREE-OF-FREEDOM (3 DOF) MODEL

Steering and Braking Control Inputs and (Optional) Speed Control Feedback

$$\delta_w = K_{sw}\,\delta_{sw} / 57.3$$

$$F_{bi} = K_{bf}\,\delta_{bf} / h_f \qquad i = 1,2$$

$$= K_{br}\,\delta_{bp} / h_r \qquad i = 3,4$$

$$F_t = \tfrac{1}{2}\min\{-K_{sc}(u_h - u_{cmd}),\ T_{d\,max}\}/h_r \qquad \delta_b \neq 0$$

$$= 0 \qquad \delta_b = 0$$

where

$$\delta_{bp} = \delta_b\,\delta_{bp_{max}}$$

with

$$F_{bf_{max}} = \tfrac{1}{2}\,W\,SNR\,\mu_{xf}\,\frac{d_r + SNR\,\mu_{xr}\,h_{cg}}{d_f + d_r + h_{cg}\,SNR(\mu_{xr} - \mu_{xf})}$$

$$F_{br_{max}} = \tfrac{1}{2}\,W\,SNR\,\mu_{xr}\,\frac{d_f - SNR\,\mu_{xf}\,h_{cg}}{d_f + d_r + h_{cg}\,SNR(\mu_{xr} - \mu_{xf})}$$

$$\delta_{bp_{max}} = \max\{F_{bf_{max}}\,h_f / K_{bf},\ F_{br_{max}}\,h_f / K_{br}\}$$

Wheel Contact Point Velocities in Horizontal Body Coordinates

$$u_{h1} = u_h - \omega_z t_f$$

$$u_{h2} = u_h + \omega_z t_f$$

$$u_{h3} = u_h - \omega_z t_r$$

$$u_{h4} = u_h + \omega_z t_r$$

$$v_{h2} = v_{h1} = v_h + \omega_z d_f$$

$$v_{h4} = v_{h3} = v_h - \omega_z d_r$$

Tire and Suspension Forces in Wheel Coordinates

$$F_{n1} = W_1 - K_x F_{hx} - K_{y1} F_{hy}$$

$$F_{n2} = W_2 - K_x F_{hx} + K_{y2} F_{hy}$$

$$F_{n3} = W_3 + K_x F_{hx} - K_{y3} F_{hy}$$

$$F_{n4} = W_4 + K_x F_{hx} + K_{y4} F_{hy}$$

$$F_{ci} = -\min\{F_{bi}, F_{cmi}\} \operatorname{sgn}(u_{hi}) \qquad i = 1, 2$$

$$= -\min\{F_{bi}, F_{cmi}\} \operatorname{sgn}(u_{hi}) + \min\{F_t, \mu_{xi} F_{ni}\} \qquad i = 3, 4$$

$$F_{si} = -\min\{|\tfrac{1}{2} \mu_{yi} \bar{\beta}_i (3 - \bar{\beta}_2) F_{ni} + F_{bi} \tan \beta_i|, F_{smi}\} \operatorname{sgn}(\beta_i) \qquad i = 1, 2, 3,$$

where

$$F_{cmi} = \frac{\mu_{yi} F_{ni}}{[(\mu_{yi} / \mu_{xi})^2 = \tan^2 \beta_i]^{\frac{1}{2}}} \qquad i = 1, 2, 3, 4$$

$$F_{smi} = [(\mu_{yi} F_{ni})^2 - (\mu_{yi} / \mu_{xi})^2 F_{ci}{}^2]^{\frac{1}{2}} \qquad i = 1, 2, 3, 4$$

$$\beta_i = \tan^{-1}\{v_{hi} / |u_{hi}|\} - \delta_w \operatorname{sgn}(u_{hi}) \qquad i = 1, 2$$

$$= \tan^{-1}\{v_{hi} / |u_{hi}|\} \qquad i = 3, 4$$

$$\bar{\beta}_i = \min\{|\beta_i| / \beta_{si}, 1\} \operatorname{sgn}(\beta_i) \qquad i = 1, 2, 3, 4$$

with

$$\left.\begin{aligned} W_i &= \tfrac{1}{2} W \frac{d_r}{d_f + d_r} \\ K_{yi} &= \tfrac{1}{2} \frac{h_{cg}}{t_f} \frac{K_f}{K_f + K_r} \\ \mu_{xi} &= SNR\ \mu_{xf} \\ \mu_{yi} &= SNR\ \mu_{yf} \\ \beta_{si} &= \beta_{sf} / 57.3 \end{aligned}\right\} i = 1, 2 \qquad \left.\begin{aligned} W_i &= \tfrac{1}{2} W \frac{d_f}{d_f + d_r} \\ K_{yi} &= \tfrac{1}{2} \frac{h_{cg}}{t_r} \frac{K_r}{K_f + K_r} \\ \mu_{xi} &= SNR\ \mu_{xr} \\ \mu_{yi} &= SNR\ \mu_{yr} \\ \beta_{si} &= \beta_{sr} / 57.3 \end{aligned}\right\} i = 3, 4$$

and

$$h_{cg} = [(z_f + h_f)\, d_f + (z_r + h_r)\, d_r] / (d_f + d_r)$$

$$K_x = \tfrac{1}{2} \frac{h_{cg}}{d_f + d_r}$$

<u>Total Applied Forces and Moments in Horizontal Coordinates</u>

$$F_{hx} = F_{x1} + F_{x2} + F_{x3} + F_{x4}$$

$$F_{hy} = F_{y1} + F_{y2} + F_{y3} + F_{y4}$$

$$T_{hz} = t_f\,(F_{x2} - F_{x1}) + t_r\,(F_{x4} - F_{x3}) + d_f\,(F_{y1} + F_{y2}) - d_r\,(F_{y3} - F_{y4})$$

where

$$F_{x1} = F_{c1} \cos \delta_w - F_{s1} \sin \delta_w$$

$$F_{x2} = F_{c2} \cos \delta_w - F_{s2} \sin \delta_w$$

$$F_{x3} = F_{c3}$$

$$F_{x4} = F_{c4}$$

$$F_{y1} = F_{c1} \sin \delta_w + F_{s1} \cos \delta_w$$

$$F_{y2} = F_{c2} \sin \delta_w + F_{s2} \cos \delta_w$$

$$F_{y3} = F_{s3}$$

$$F_{y4} = F_{s4}$$

State Derivatives for Velocities Above Threshold ($|u_h| > u_{th}$ or $|v_h| > v_{th}$)

- Linear Velocity in Horizontal Body Coordinates:

$$\dot{u}_h = \dot{\psi} v_h + F_{hx}/M$$

$$\dot{v}_h = -\dot{\psi} u_h + F_{hy}/M$$

where

$$M = W/g$$

- Linear Position in Inertial Coordinates:

$$\dot{x} = u_h \cos \psi - v_h \sin \psi$$

$$\dot{y} = u_h \sin \psi + v_h \cos \psi$$

- Angular Rates about Body Axes:

$$\dot{\omega}_z = [(I_{xx} - I_{yy}) \omega_x \omega_y + T_{hz} + \theta T_{hx} - \phi T_{hy}] / I_{zz}$$

- Attitude in Inertial Coordinates:

$$\dot{\psi} = \omega_z + \omega_y \phi$$

State Derivatives for Velocities Below Threshold ($|u_h| \leq u_{th}$, $|v_h| \leq v_{th}$)

$$\dot{\omega}_z = 0, \quad \omega_z = u_h \delta_w / (d_f + d_r)(1 + K_{stab} u_h^2)$$

$$\dot{\psi} = \omega_z$$

$$\dot{u}_h = \dot{\psi} v_h + F_{hx}/M$$

$$\dot{v}_h = 0, \quad v_h = (1 - u_h / gC_{sr}) d_r \omega_z$$

$$\dot{x} = u_h \cos \psi - v_h \sin \psi$$

$$\dot{y} = u_h \sin \psi + v_h \cos \psi$$

with

$$C_{sf} = \frac{3}{2}\ (57.3)\ SNR\ \mu_{yf} / \beta_{sf}$$

$$C_{sr} = \frac{3}{2}\ (57.3)\ SNR\ \mu_{yr} / \beta_{sr}$$

$$K_{stab} = (1/C_{sf} - 1/C_{sr})\ /\ g\ (d_f + d_r)$$

$$u_{th} = 2\ g\ C_{sr}\ \Delta t$$

$$v_{th} = 2\ g\ SNR\ \Delta t\ (\mu_{yf}\ d_r + \mu_{yr}\ d_f)\ /\ (d_f + d_r)$$

TWO-DEGREE-OF-FREEDOM (2 DOF) LATERAL-AXIS MODEL

State Derivatives for Velocity Above Threshold ($|u_h| > u_{th}$)

$$\dot{v}_h = Y_v\ v_h + (Y_r - u_{h0})\ \omega_z + Y_{\delta_w}\ \delta_w$$

$$\dot{\omega}_z = N_v\ v_h + N_r\ \omega_z + N_{\delta_w}\ \delta_w$$

$$\dot{x} = u_h \cos\psi - v_h \sin\psi$$

$$\dot{y} = u_h \sin\psi - v_h \cos\psi$$

$$\dot{\psi} = \omega_z$$

where

$$u_h = u_{h0}$$

$$\delta_w = K_{sw}\ \delta_{sw} / 57.3$$

with

$$C_{sf} = 1.5\ (57.3)\ SNR\ \mu_{xf} / \beta_{sf}$$

$$C_{sr} = 1.5\ (57.3)\ SNR\ \mu_{xr} / \beta_{sr}$$

$$Y_v = -\frac{g\ d_f\ d_r}{(d_f + d_r)\ u_{h0}}\ (C_{sf}/d_f + C_{sr}/d_r)$$

$$Y_r = - \frac{g\, d_f\, d_r}{(d_f + d_r)\, u_{h0}} (C_{sf} - C_{sr})$$

$$N_v = - \frac{W\, d_f\, d_r}{(d_f + d_r)\, u_{h0}\, I_{zz}} (C_{sf} - C_{sr})$$

$$N_r = - \frac{W\, d_f\, d_r}{(d_f + d_r)\, u_{h0}\, I_{zz}} (d_f\, C_{sf} + d_r\, C_{sr})$$

$$Y_{\delta_w} = \frac{g\, d_r}{d_f + d_r} C_{sf}$$

$$N_{\delta_w} = \frac{W\, d_f\, d_r}{(d_f + d_r)\, I_{zz}} C_{sf}$$

<u>State Derivatives for Velocity Below Threshold ($|u_h| \le u_{th}$)</u>

$$v_h = 0, \quad v_h = (1 - u_h/gC_{s_r})\, d_r\, \omega_z$$

$$\dot{\omega}_z = 0, \quad \omega_z = u_{h0}\, \delta_w /(d_f + d_r)(1 + K_{stab}\, u_{h0}{}^2)$$

$$\dot{x} = u_h \cos \psi - v_h \sin \psi$$

$$\dot{y} = u_h \sin \psi + v_h \cos \psi$$

$$\dot{\psi} = \omega_z$$

where

$$u_h = u_{h0}$$

$$\delta_w = K_{sw}\, \delta_{sw} / 57.3$$

with

$$K_{stab} = (1/C_{sf} - 1/C_{sr}) / g\, (d_f + d_r)$$

$$u_{th} = 2\, g\, C_{sr}\, \Delta t$$

ONE-DEGREE-OF-FREEDOM (1 DOF) LONGITUDINAL-AXIS MODEL

$$\dot{u}_h = F_{hx}/M$$

$$\dot{x} = u_h$$

where

- No Wheels Locked: $\delta_{bp} \leq \delta_{bp_{min}}$

$$F_{hx} = -2 \left(\frac{K_{bf}}{h_f} + \frac{K_{br}}{h_r} \right) \delta_{bp} \, \mathrm{sgn}\,(u_h)$$

- Front Wheels Locked: $\delta_{bf_{th}} \leq \delta_{bp} \leq \delta_{br_{th}}$

$$F_{hx} = -2 \left[\frac{\frac{1}{2} W d_r SNR \mu_{xf} + K_{br} (d_f + d_r) \delta_{bp}/h_r}{d_f + d_r - SNR \mu_{xf} h_{cg}} \right] \mathrm{sgn}\,(u_h)$$

- Rear Wheels Locked: $\delta_{br_{th}} \leq \delta_{bp} \leq \delta_{bf_{th}}$

$$F_{hx} = -2 \left[\frac{\frac{1}{2} W d_f SNR \mu_{xr} + K_{bf} (d_f + d_r) \delta_{bp}/h_f}{d_f + d_r + SNR \mu_{xr} h_{cg}} \right] \mathrm{sgn}\,(u_h)$$

- All Wheels Locked: $\delta_{bp} \geq \delta_{bp_{max}}$

$$F_{hx} = -2 \left(F_{bf_{max}} + F_{br_{max}} \right) \mathrm{sgn}\,(u_h)$$

where

$$\delta_{bp} = \delta_b \cdot \delta_{bp_{max}}$$

with

$$F_{bf_{max}} = \frac{1}{2} W \, SNR \, \mu_{xf} \frac{d_r + SNR \, \mu_{xr} h_{cg}}{d_f + d_r + h_{cg} SNR (\mu_{xr} - \mu_{xf})}$$

$$F_{br_{max}} = \frac{1}{2} W \, SNR \, \mu_{xr} \frac{d_f - SNR \, \mu_{xf} h_{cg}}{d_f + d_r + h_{cg} SNR (\mu_{xr} - \mu_{xf})}$$

$$\delta_{bf_{th}} = \frac{\frac{1}{2} W \; d_r}{K_{bf} (d_f + d_r)/SNR \; \mu_{xf} \, h_f - \left(\frac{K_{bf}}{h_f} + \frac{K_{br}}{h_r}\right) h_{cg}}$$

$$\delta_{br_{th}} = \frac{\frac{1}{2} W \; d_f}{K_{br} (d_f + d_r)/SNR \; \mu_{xr} \, h_r + \left(\frac{K_{bf}}{h_f} + \frac{K_{br}}{h_r}\right) h_{cg}}$$

$$\delta_{bp_{min}} = \min \{ \delta_{bf_{th}}, \; \delta_{br_{th}} \}$$

$$\delta_{bp_{max}} = \max \{ F_{bf_{max}} \, h_f / K_{bf}, \; F_{br_{max}} \, h_r / K_{br} \}$$

and $h_{cg} = [(z_f + h_f) \, d_f + (z_r + h_r) \, d_r] \, / \, (d_f + d_r)$

APPENDIX E

DERIVATIONS OF MANEUVER DECISION MODEL PROBABILITIES

This appendix derives probability expressions from corresponding logical expressions for the maneuver decision model described in Section 9. In addition, it derives probabilities of adjacent vehicles occupying each of the safe-maneuvering regions defined in Figure 9-1.

Consider first the probability that one or more adjacent vehicles (AV) occupy any one of the regions identified in Figure 9-1. The general situation for a string of vehicles all of length ℓ is illustrated in Figure E-1. A vehicle is considered to occupy the safe-maneuvering region Q, with length L, if any part of the vehicle lies within region Q. Thus for a vehicle in the vicinity of region Q, the vehicle will remain in region Q for a distance of $L + \ell$ as region Q is shifted a distance of one headway (h), provided the headway is greater than $L + \ell$. If the headway is less than $L + \ell$, a new vehicle enters the region before the old vehicle leaves. Thus, to avoid counting occupancies more than once, the region is, in effect, occupied only for a distance of h as Q is shifted through the same distance. The probability that region Q is occupied at any time is given by (recall that c = minimum headway and $\bar{h}$ = mean headway)

$$P_q = \frac{1}{\bar{h}} \int_0^\infty \min \{h, L + \ell\} \; p(h)dh$$

We consider two cases:

<u>Case 1:</u> $c < L + \ell$

$$P_q = \frac{1}{\bar{h}} \int_0^\infty \min \{h, L + \ell\} \frac{1}{\bar{h} - c} \exp - \{(h - c)/(\bar{h} - c)\} \, dh$$

$$= \frac{1}{\bar{h}} \int_c^\infty \frac{h}{\bar{h} - c} \exp \{ -(h - c)/(\bar{h} - c) \} \, dh$$

$$+ \frac{L + \ell}{\bar{h}} \int_{L+\ell}^\infty \frac{1}{\bar{h} - c} \exp \{-(h - c)/\bar{h} - c)\} dh$$

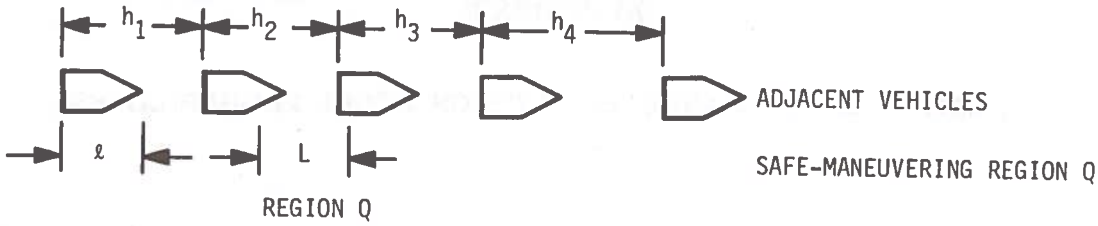

FIGURE E-1. STRING OF ADJACENT LANE VEHICLES

$$= -\frac{1}{\bar{h}}(h - \bar{h} - c)\exp\{-(h-c)/(\bar{h}-c)\}\Big|_{c}^{L+\ell}$$

$$-\frac{L+\ell}{\bar{h}}\exp\left[-(h-c)/(\bar{h}-c)\right]\Big|_{L+\ell}^{\infty}$$

$$= 1 - (1 - \frac{c}{\bar{h}})\exp\{-(L+\ell-c)/(\bar{h}-c)\}$$

<u>Case 2:</u> $c \geq L + \ell$

$$P_q = \frac{L+\ell}{\bar{h}}\int_0^{\infty} p(h)dh = \frac{L+\ell}{\bar{h}}$$

Assuming symmetry and independence between adjacent left and right lanes of traffic, and letting $\ell = \ell_{av}$ and $L = \ell_f$, ℓ_r, and $\ell_f + \ell_r$, respectively, gives the first three results summarized in Table 9-3. In addition, two other probability identities are presented in Table 9-3 for later use.

For the remainder of this appendix, results are separated into two subsections: one for scenarios 1 and 2, and one for scenarios 6 and 9, in accordance with the models presented in Section 9.

SCENARIOS 1 AND 2

Referring to the logical expressions given in Table 9-4, along with the probabilities in Table 9-3, and observing the lack of correlation between terms, conditional probabilities for X are given by

$$P(X|V) = P_{f+r}P_{f+r} = P_{f+r}^2$$

$$P(X|\overline{V}) = P_aP_{f+r}P_{f+r} + (1 - P_a)P_f\,P_f$$

$$= P_aP_{f+r}^2 + (1 - P_a)P_f^2$$

and

$$P(\overline{X}|V) = 1 - P(X|V)$$

$$P(\overline{X}|\overline{V}) = 1 - P(X|\overline{V})$$

Hence, the conditional probabilities for B, S, and C in Table 9-4 follow directly.

Now, for the correlation expressions, we first rewrite Y as

$$Y = [(\overline{L}1 \cdot L2) \cdot (R1 + R2) + (\overline{R}1 \cdot R2) \cdot (L1 + L2) + LT \cdot \overline{R}1 \cdot (\overline{L1} \cdot L2)$$
$$+ RT \cdot \overline{L}1 \cdot (\overline{R}1 \cdot R2)] \cdot \overline{A} \cdot \overline{V}$$

where parentheses are used to group states which are correlated with each other. Note further that the first two terms within brackets are correlated with each other, while each is correlated with the third and fourth terms, which are themselves uncorrelated. Thus, taking into account the correlations within and between terms, we get the conditional probabilities*

$$P(\overline{X} \cdot Y|\overline{V}) = P(Y|\overline{V})$$

$$= [P_{\overline{f}r}P_{f+r} + P_{\overline{f}r}P_{f+r} + \left(\tfrac{1}{2}(1 - P_f)P_{\overline{f}r} + \tfrac{1}{2}(1 - P_f)P_{\overline{f}r}\right)$$

$$- P_{\overline{f}r}^2 - (\tfrac{1}{2}P_{\overline{f}r}^2 + \tfrac{1}{2}P_{\overline{f}r}^2) - (\tfrac{1}{2}P_{\overline{f}r}^2 + \tfrac{1}{2}P_{\overline{f}r}^2)$$

$$+ (\tfrac{1}{2}P_{\overline{f}r}^2 + \tfrac{1}{2}P_{\overline{f}r}^2)]\ (1 - P_a)$$

---

*Since the third and fourth terms are uncorrelated with each other, we group these terms to get an expression of the general form X = A + B + C, for which P(X) = P(A + B + C) = P(A) + P(B) + P(C) - P(AB) - P(AC) - P(BC) + P(ABC).

$$= (1 - P_a)\, P_{\bar{f}r}\; [2P_{f+r} + (1 - P_f) - 2P_{\bar{f}r}$$

$$= (1 - P_a)\; [2P_f + (1 - P_f)]\; (P_{f+r} - P_f)$$

$$= (1 - P_a)\; (1 + P_f)\; (P_{f+r} - P_f)$$

$$P(X \cdot Z|V)$$

$$= (P_{\bar{f}r}P_{f+r} + P_{\bar{f}r}P_{f+r} - P_{\bar{f}r}^2)\; (1 - P_a)$$

$$= (1 - P_a)\; P_{\bar{f}r}\; (2P_{f+r} - P_{\bar{f}r})$$

$$= (1 - P_a)\; (P_{f+r}^2 - P_f^2)$$

$$P(\bar{X} \cdot Z|V) = (1 - P_a)\; (1 - P_{f+r}^2)$$

Hence, the conditional probabilities for COLL and LOOK in Table 9-4 are given by*

$$P(COLL|B \cdot \bar{V}) = P(B \cdot COLL|\bar{V})/P(B|\bar{V}) = P(B_0 \cdot \bar{X} + X) \cdot (S_0 + C_0) \cdot Y|\bar{V})/P(B|\bar{V}$$

$$= P(S_0 + C_0)\; P(X \cdot Y|\bar{V})/P(B|\bar{V}) = 0$$

$$P(COLL|S \cdot \bar{V}) = P(S \cdot COLL|\bar{V})/P(S|\bar{V}) = P(S_0 \cdot \bar{X} \cdot Y|\bar{V})/P(S_0 \cdot \bar{X}|\bar{V})$$

$$= P(\bar{X} \cdot Y|\bar{V})/P(\bar{X}|\bar{V}) = (1 - P_a)(1 + P_f)(P_{f+r} - P_f)/P(\bar{X}|\bar{V})$$

$$P(COLL|C \cdot \bar{V}) = P(C \cdot COLL|\bar{V})/P(C|\bar{V}) = P(C_0 \cdot \bar{X} \cdot Y|\bar{V})/P(C_0 \cdot \bar{X}|\bar{V})$$

$$= P(\bar{X} \cdot Y|\bar{V})/P(\bar{X}|\bar{V}) = (1 - P_a)(1 + P_f)(P_{f+r} - P_f)/P(\bar{X}|\bar{V})$$

and

$$P(LOOK|B \cdot V) = P(B \cdot LOOK|V)/P(B|V) = P(B_0 \cdot \bar{X} + X) \cdot (S_0 + C_0) \cdot Z|V)/P(B$$

$$= P(S_0 + C_0) \cdot X \cdot Z|V)/P(B|V)$$

$$= (P_{s_0} + P_{c_0})(1 - P_a)(P_{f+r}^2 - P_f^2)/P(B|V)$$

---

*Note that $B_0 \cdot (S_0 + C_0) = 0$, $S_0 \cdot (S_0 + C_0) = S_0$, $C_0 \cdot (S_0 + C_0) = C_0$, and $X \cdot Y = 0$ and that B_0, S_0, and C_0 are independent of X, Y, Z, and V.

$$P(LOOK|S \cdot V) = P(S \cdot LOOK|V)/P(S|V) = P(S_0 \cdot \bar{X} \cdot Z|V)/P(S_0 \cdot \bar{X}|V)$$

$$= P(\bar{X} \cdot Z|V)/P(\bar{X}|V) = 1 - P_a$$

$$P(LOOK|C \cdot V) = P(C \cdot LOOK|V)/P(C|V) = P(C_0 \cdot \bar{X} \cdot Z|V)/P(C_0 \cdot \bar{X}|V)$$

$$= P(\bar{X} \cdot Z|V)/P(\bar{X}|V) = 1 - P_a$$

SCENARIOS 6 and 9

Referring to the logical expressions in Table 9-5 together with the probabilities given in Table 9-3, and observing the lack of correlation between terms, conditional probabilities for X are given by:

$$P(X|V) = P_{f+r}$$

$$P(X|\bar{V}) = P_a P_{f+r} + (1 - P_a) P_f$$

and

$$P(\bar{X}|V) = 1 - P(X|V)$$

$$P(\bar{X}|\bar{V}) = 1 - P(X|\bar{V})$$

Hence the conditional probabilities for B, S, and C given in Table 9-5 follow directly.

Conditional probabilities for the correlation expressions in Table 9-5 are given by

$$P(\bar{X} \cdot Y|\bar{V}) = P(Y|\bar{V}) = P_{\bar{f}r}(1 - P_a) = (1 - P_a)(P_{f+r} - P_f)$$

$$P(X \cdot Z|V) = P_{\bar{f}r}(1 - P_a) = (1 - P_a)(P_{f+r} - P_f)$$

$$P(\bar{X} \cdot Z|V) = (1 - P_a)(1 - P_{f+r})$$

Thus, the conditional probabilities for COLL and LOOK in Table 9-5 are given by (following the development in the previous subsection):

$$P(\text{COLL} | B \cdot \overline{V}) = 0$$

$$P(\text{COLL} | S \cdot \overline{V}) = (1 - P_a)(P_{f+r} - P_f)/P(\overline{X} | \overline{V})$$

$$P(\text{COLL} | C \cdot \overline{V}) = (1 - P_a)(P_{f+r} - P_f)/P(\overline{X} | \overline{V})$$

and

$$P(\text{LOOK} | B \cdot V) = (P_{s_0} + P_{c_0})(1 - P_a)(P_{f+r} - P_f)/P(B | V)$$

$$P(\text{LOOK} | S \cdot V) = 1 - P_a$$

$$P(\text{LOOK} | C \cdot V) = 1 - P_a$$

APPENDIX F

NOMINAL DATA

Nominal values for DRIVEM parameters and variables are contained in this appendix. The basis for these data is discussed in Appendix G.

In the tables that follow, parameter values and tabular data are presented in the same order as the samples output file list shown in Figure C-6. Nominal values for a majority of the model parameters vary depending on user-selected options such as scenario, vehicle-model degrees of freedom, and ambient-illumination conditions. These variations are noted in each data table. Parameters not involved in model computations under certain conditions are indicated as not applicable (N/A).

LIST OF TABLES

TABLE F-1. NOMINAL PARAMETER VALUES FOR SUBJECT VEHICLE INITIAL CONDITIONS

Mnemonic	Parameter	Scenario: 1	2	3	4	5	6	7	8	9	10	11
UH0	u_{h_0}	55.0	→	40.0	→	→	55.0	40.0	→	55.0	→	→
VH0	v_{h_0}	0.0	→	→	→	→	→	→	→	→	→	→
WH0	w_{h_0}	0.0	→	→	→	→	→	→	→	→	→	→
X0	x_0	0.0	→	→	→	→	→	→	→	→	→	→
Y0	y_0	0.0	→	→	→	→	→	→	→	→	→	→
Z0	z_0	0.0	→	→	→	→	→	→	→	→	→	→
WX0	w_{x_0}	0.0	→	→	→	→	→	→	→	→	→	→
WY0	w_{y_0}	0.0	→	→	→	→	→	→	→	→	→	→
WZ0	w_{z_0}	0.0	→	→	→	→	→	→	→	→	→	→
PHI0	ϕ_0	0.0	→	→	→	→	→	→	→	→	→	→
THE0	θ_0	0.0	→	→	→	→	→	→	→	→	→	→
PSI0	ψ_0	0.0	→	→	→	→	→	→	→	→	→	→

TABLE F-2. NOMINAL PARAMETER VALUES FOR SUBJECT-VEHICLE MODEL

Mnemonic	Parameter	Model Degrees of Freedom			
		6 DOF	3 DOF	2 DOF	1 DOF
WEIGHT	W	3771.0	→	→	→
IXX	I_{xx}	313.0	N/A	→	→
IYY	I_{yy}	1917.0	N/A	→	→
IZZ	I_{zz}	2405.0	→	→	N/A
DF	d_f	4.11	→	→	→
DR	d_r	5.73	→	→	→
TF	t_f	2.49	→	N/A	→
TR	t_r	2.58	→	N/A	→
ZF	z_f	0.9	→	N/A	0.9
ZR	z_r	0.9	→	N/A	0.9
HF	h_f	1.1	→	N/A	1.1
HR	h_r	1.1	→	N/A	1.1
KF	K_f	1260.0	→	N/A	→
KR	K_r	1440.0	→	N/A	→
CF	C_f	52.0	N/A	→	→
CR	C_r	100.0	N/A	→	→
MUXF	μ_{xf}	0.85	→	N/A	0.85
MUXR	μ_{xr}	0.88	→	N/A	0.88
MUYF	μ_{xf}	0.96	→	→	N/A
MUYR	μ_{xr}	1.02	→	→	N/A
BETASF	β_{sf}	20.0	→	→	N/A
BETASR	β_{sr}	17.0	→	→	N/A
SNR	SNR	1.0	→	→	→
KSW	K_{sw}	0.07	→	→	N/A
KBF	K_{bf}	0.6	→	N/A	0.6
KBR	K_{br}	0.4	→	N/A	0.4
KSC	K_{sc}	0.0	→	N/A	→
UCMD	U_{cmd}	0.0	→	N/A	→
TDMAX	$T_{d_{max}}$	0.0	→	N/A	→

TABLE F-3. NOMINAL PARAMETER VALUES FOR DRIVER OPEN- AND CLOSED-LOOP CONTROL MODELS

Mnemonic	Parameter	Scenario: 1	2	3	4	5	6	7	8	9	10	11
MANDEC	-	0.0										
TAUR	τ_r	0.2										
TAUP	τ_p	3.0										
WC	ω_c	3.5										
VETH	$v_{e_{th}}$	2.0										
YETH	$y_{e_{th}}$	2.0										
ABR	A_{br}	0.0										
ABSTB	A_{bst_b}	0.75										
ABSTC	A_{bst_c}	0.60										
ASWS	A_{sw_s}	90.0										
ASWC	A_{sw_c}	90.0										
TSW	T_{sw}	1.1		1.5			1.1	1.5		1.1		
SWMAX	SW_{max}	720.										
SWRMAX	SWR_{max}	600.										

TABLE F-4. NOMINAL PARAMETER VALUES FOR SCENARIO DEFINITION

Mnemonic	Parameter	Scenario: 1	2	3	4	5	6	7	8	9	10	11
HOV	h_{ov}	81.0	→	59.0	→	→	N/A	→	→	→	→	→
UOV0	u_{ov_0}	55.0	→	40.0	→	→	N/A	→	→	→	→	→
DOVG	d_{ov_g}	0.5	→		→	→	N/A	→	→	→	→	→
HLV	$h_{\ell v}$	N/A	81.0	N/A	→	59.0	N/A	→	→	→	→	→
ULV0	$u_{\ell v_0}$	NA	55.0	N/A	→	40.0	N/A	→	→	→	→	→
DLVG	$d_{\ell v_g}$	N/A	0.25	N/A	→	0.25	N/A	→	→	→	→	→
HNVMIN	$h_{nv_{min}}$	N/A	→	→	29.0	→	N/A	→	→	→	→	40.0
HNVAVE	$h_{nv_{ave}}$	N/A	→	→	1056.0	→	N/A	→	→	→	→	1056.0
UNV0	u_{nv_0}	N/A	→	→	40.0	→	N/A	→	→	→	→	55.0
DISTSO	d_{so}	N/A	→	→	→	→	500.0	→	→	→	→	→
DISTNS	d_{ns}	N/A	→	→	0.0	→	N/A	→	→	→	→	0.0
PSIB	ψ_b	N/A	→	→	→	→	45.0	→	→	N/A	→	→
LW	LW	12.0	→	N/A	12.0	→	→	→	→	→	→	→
TAUD	τ_d	1.5	→	→	→	→	→	→	→	→	→	→
TAUOVD	τ_{ov_d}	N/A	1.5	N/A	→	1.5	N/A	→	→	→	→	→

TABLE F-5. NOMINAL PARAMETER VALUES FOR DRIVER MANEUVER-DECISION MODEL

Mnemonic	Parameter	Scenario: 1	2	3	4	5	6	7	8	9	10	11
LAV	ℓ_{av}	20.0	→	N/A	20.0	→	→	N/A	→	20.0	N/A	→
HAVMIN	$h_{av_{min}}$	40.0	→	N/A	→	→	40.0	N/A	→	40.0	N/A	→
HAVAVE	$h_{av_{ave}}$	176.0	→	N/A	→	→	176.0	N/A	→	176.0	N/A	→
LF	ℓ_f	15.0	→	N/A	→	15.0	→	N/A	→	15.0	N/A	→
LR	ℓ_r	15.0	→	N/A	→	15.0	→	N/A	→	15.0	N/A	→
PB0	P_{b_0}	0.4	→	N/A	0.4	→	→	→	→	→	→	→
PS0	P_{s_0}	0.08	→	N/A	0.08	→	→	→	→	→	→	→
PA	P_a	0.5	→	N/A	→	→	0.5	N/A	→	0.5	N/A	→
TTHRSH	t_{th}	1.0	→	N/A	→	→	1.0	N/A	→	1.0	N/A	→
DTHRSH	d_{th}	N/A	→	→	1076.0	→	N/A	→	→	→	→	1392.0
TLOOK	t_{look}	1.0	→	N/A	→	→	1.0	N/A	→	1.0	N/A	→

TABLE F-6. NOMINAL PARAMETER VALUES FOR DRIVER EVENT-DETECTION MODEL: "DAY 1 " CONDITION

		Scenario: (Day 1)										
Mnemonic	Parameter	1	2	3	4	5	6	7	8	9	10	11
ESKY	E_{sky}	400.0										
ESUN	E_{sun}	8000.0										
RO	R_o	N/A					0.5			0.12	0.5	
EO	E_o	N/A										
IO	I_o	70.0					N/A					
BSUNO	β_{sun_o}	N/A					90.0					
RB	R_b	0.20					0.09			0.37		
EB	E_b	N/A										
IB	I_b	N/A										
BSUNB	β_{sun_b}	90.0					45.0					
LSKY	L_{sky}	2700.0										
LSUR	L_{sur}	2400.0										
TRANS	T	0.7										
KL	K_ℓ	N/A	0.5	N/A		0.5	N/A					
VO	V_o	0.33					4.0			3.0	1.0	
HO	H_o	0.33					14.0			1.0	3.0	
PLITE	P_{lite}	N/A	0.2	N/A		0.2	N/A					
HRTH	Δh	0.12					N/A					
HPER	h_{per}	10.0					N/A					
SIGC	σ_c	0.5										
KV1	K_{v1}	6.7										
KV2	K_{v2}	6.7										
ALPHMN	α_{min}	0.5										
HEYE	H_{eye}	4.0										
HLITE	H_{lite}	2.5										
HOBJ	H_{obj}	2.5								3.5	0.5	

TABLE F-6. (concluded)

Mnemonic	Parameter	Scenario: (Day 1) 1	2	3	4	5	6	7	8	9	10	11
TAUBM	$\overline{\tau}_b$	0.16										
TAUBS	σ_{τ_b}	0.0										
TAURDM	$\overline{\tau}_{rd}$	1.0										
TAURDS	$\sigma_{\tau_{rd}}$	0.37										

TABLE F-7. NOMINAL PARAMETER VALUES FOR DRIVER EVENT-DETECTION MODEL: "DAY 2" CONDITION

Mnemonic	Parameter	Scenario: (Day 2) 1	2	3	4	5	6	7	8	9	10	11
ESKY	E_{sky}	1480.0										
ESUN	E_{sun}	8000.0										
RO	R_o	N/A					0.5			0.12	0.5	
EO	E_o	N/A										
IO	I_o	70.0					N/A					
BSUNO	β_{sun_o}	N/A					69.0	45.0				
RB	R_b	0.20					0.16			0.32		
EB	E_b	N/A										
IB	I_b	N/A										
BSUNB	β_{sun_b}	45.0										
LSKY	L_{sky}	1700.0										
LSUR	L_{sur}	1700.0										
TRANS	T	0.7										
KL	K_ℓ	N/A	0.5	N/A		0.5	N/A					
VO	V_o	0.33					4.0			3.0	1.0	
HO	H_o	0.33					14.0			1.0	3.0	
PLITE	P_{lite}	N/A	0.2	N/A		0.2	N/A					
HRTH	Δh	0.12					N/A					
HPER	h_{per}	10.0					N/A					
SIGC	σ_c	0.5										
KV1	K_{v1}	6.7										
KV2	K_{v2}	6.7										
ALPHMIN	α_{min}	0.5										
HEYE	H_{eye}	4.0										
HLITE	H_{lite}	2.5										
HOBJ	H_{obj}	2.5								3.5	0.5	

TABLE F-7. (concluded)

Mnemonic	Parameter	Scenario: (Day 2) 1	2	3	4	5	6	7	8	9	10	11
TAUBM	$\overline{\tau}_b$	0.16	→	→	→	→	→	→	→	→	→	→
TAUBS	σ_{τ_b}	0.0	→	→	→	→	→	→	→	→	→	→
TAURDM	$\overline{\tau}_{rd}$	1.0	→	→	→	→	→	→	→	→	→	→
TAURDS	$\sigma_{\tau_{rd}}$	0.37	→	→	→	→	→	→	→	→	→	→

TABLE F-8. NOMINAL PARAMETER VALUES FOR DRIVER EVENT-DETECTION MODEL: "NIGHT" CONDITION

		Scenario: (Night)										
Mnemonic	Parameter	1	2	3	4	5	6	7	8	9	10	11
ESKY	E_{sky}	N/A										→
ESUN	E_{sun}	N/A										→
RO	R_o	N/A							→	0.12	0.50	→
EO	E_o	N/A							→	0.0		→
IO	I_o	70.0				→	N/A					→
BSUNO	β_{sun_o}	N/A										→
RB	R_b	N/A							→	0.13		→
EB	E_b	N/A							→	0.0		→
IB	I_b	2.0				→	N/A					→
BSUNB	β_{sun_b}	N/A										→
LSKY	L_{sky}	0.1				→	N/A		→	0.1		→
LSUR	L_{sur}	0.3				→	N/A		→	0.3		→
TRANS	T	0.7				→	N/A		→	0.7		→
KL	K_ℓ	N/A	0.5	N/A	→	0.5	N/A					→
VO	V_o	0.33				→	N/A		→	3.0	1.0	→
HO	H_o	0.33				→	N. A		→	1.0	3.0	→
PLITE	P_{lite}	N/A	0.2	N/A	→	0.2	N/A					→
HRTH	Δh	0.12				→	N/A					→
HPER	h_{per}	10.0				→	N/A					→
SIGC	σ_c	0.5				→	N/A		→	0.5		→
KV1	K_{v1}	6.7				→	N/A		→	6.7		→
KV2	K_{v2}	6.7				→	N/A		→	6.7		→
ALPHMN	α_{min}	0.5				→	N/A		→	0.5		→
HEYE	H_{eye}	4.0				→	N/A		→	4.0		→
HLITE	H_{lite}	2.5				→	N/A		→	2.5		→
HOBJ	H_{obj}	2.5				→	N/A		→	3.5	0.5	→

TABLE F-8. (concluded)

Mnemonic	Parameter	Scenario: (Night) 1	2	3	4	5	6	7	8	9	10	11
TAUBM	$\overline{\tau}_b$	0.16	→	→	→	→	N/A	→	→	0.16	→	→
TAUBS	σ_{τ_b}	0.0	→	→	→	→	N/A	→	→	0.0	→	→
TAURDM	$\overline{\tau}_{rd}$	1.0	→	→	→	→	N/A	→	→	1.0	→	→
TAURDS	$\sigma_{\tau_{rd}}$	0.37	→	→	→	→	N/A	→	→	0.37	→	→

TABLE F-9. NOMINAL PARAMETER VALUES FOR COLLISION-DETERMINATION ALGORITHM

Mnemonic	Parameter	Scenario: 1	2	3	4	5	6	7	8	9	10	11
LSVF	ℓ_{svf}	7.5	→	→	→	→	→	→	→	→	→	→
LSVR	ℓ_{svr}	7.5	→	→	→	→	→	→	→	→	→	→
WSV	w_{sv}	5.7	→	→	→	→	→	→	→	→	→	→
LOV	ℓ_{ov}	15.0	→	→	→	→	→	→	→	N/A	→	→
WOV	w_{ov}	5.7	→	→	→	→	→	→	→	N/A	→	→
UHTH	$u_{h_{th}}$	2.0	→	→	→	→	→	→	→	→	→	→
VHTH	$v_{h_{th}}$	2.0	→	→	→	→	→	→	→	→	→	→

TABLE F-10. NOMINAL TABULAR DATA FOR SCAN PATTERN AND FIXED GLARE SOURCE LOCATION IN DRIVER EVENT-DETECTION MODEL: "DAY 1" AND "DAY 2" CONDITIONS

		Scenario: (Day 1 and Day 2)										
Mnemonic	Parameter	1	2	3	4	5	6	7	8	9	10	11
NCAT	N_c	5.0	→	→	→	→	→	→	→	→	→	→
PCAT(I)	P_i											
I = 1		0.683	→	0.610	0.683	→	→	→	→	→	→	→
2		0.053	→	0.030	0.053	→	→	→	→	→	→	→
3		0.022	→	0.091	0.022	→	→	→	→	→	→	→
4		0.044	→	0.015	0.044	→	→	→	→	→	→	→
5		0.005	→	0.003	0.005	→	→	→	→	→	→	→
THFM(I)	$\bar{\theta}_{f_i}$											
I = 1		0.33	→	0.30	→	→	0.33	0.89	→	→	0.26	→
2		5.0	→	→	→	→	→	→	→	→	→	→
3		-12.0	→	→	→	→	→	→	→	→	→	→
4		-18.0	→	→	→	→	→	→	→	→	→	→
5		-45.0	→	→	→	→	→	→	→	→	→	→
THFS(I)	$\sigma_{\theta_{f_i}}$											
I = 1		1.70	→	1.12	→	→	1.70	1.47	→	→	1.58	→
2		0.0	→	→	→	→	→	→	→	→	→	→
3		0.0	→	→	→	→	→	→	→	→	→	→
4		0.0	→	→	→	→	→	→	→	→	→	→
5		0.0	→	→	→	→	→	→	→	→	→	→
PSFM(I)	$\bar{\psi}_{f_i}$											
I = 1		3.98	→	4.19	→	→	3.98	3.45	→	→	0.67	→
2		40.0	→	→	→	→	→	→	→	→	→	→
3		-52.0	→	→	→	→	→	→	→	→	→	→
4		0.0	→	→	→	→	→	→	→	→	→	→
5		45.0	→	→	→	→	→	→	→	→	→	→

TABLE F-10. (continued)

Mnemonic	Parameter	Scenario: (Day 1 and Day 2) 1	2	3	4	5	6	7	8	9	10	11
PSFS(I)	$\sigma_{\psi_{f_i}}$											
I = 1		1.83	→	0.99	→	→	1.83	1.88	→	→	2.52	→
2		0.0	→	→	→	→	→	→	→	→	→	→
3		0.0	→	→	→	→	→	→	→	→	→	→
4		0.0	→	→	→	→	→	→	→	→	→	→
5		0.0	→	→	→	→	→	→	→	→	→	→
TAUFM(I)	$\bar{\tau}_{f_i}$											
I = 1		0.76	→	1.36	→	→	0.76	1.64	→	→	→	→
2		0.73	→	0.59	0.73	→	→	→	→	→	→	→
3		1.08	→	0.72	1.08	→	→	→	→	→	→	→
4		0.68	→	0.61	0.68	→	→	→	→	→	→	→
5		1.44	→	→	→	→	→	→	→	→	→	→
TAUFS(I)	$\sigma_{\tau_{f_i}}$											
I = 1		1.06	→	1.68	→	→	1.06	2.08	→	→	→	→
2		0.33	→	0.35	0.33	→	→	→	→	→	→	→
3		0.72	→	0.39	0.72	→	→	→	→	→	→	→
4		0.27	→	0.25	0.27	→	→	→	→	→	→	→
5		0.56	→	→	→	→	→	→	→	→	→	→
NGLARE	N_g	2.0	→	→	→	→	→	→	→	→	→	→
EG(I)	E_{g_i}											
I = 1		0.0	→	→	→	→	→	→	→	→	→	→
2		0.0	→	→	→	→	→	→	→	→	→	→

TABLE F-10. (concluded)

Mnemonic	Parameter	Scenario: (Day 1 and Day 2) 1	2	3	4	5	6	7	8	9	10	11
THG(I)	θ_{g_i}											
I = 1		0.0	→	→	→	→	→	→	→	→	→	→
2		0.0	→	→	→	→	→	→	→	→	→	→
PSG(I)	ψ_{g_i}											
I = 1		0.0	→	→	→	→	→	→	→	→	→	→
2		0.0	→	→	→	→	→	→	→	→	→	→

TABLE F-11. NOMINAL TABULAR DATA FOR SCAN PATTERN AND FIXED GLARE SOURCE LOCATION IN DRIVER EVENT-DETECTION MODEL: "NIGHT" CONDITION

		Scenario: (Night)										
Mnemonic	Parameter	1	2	3	4	5	6	7	8	9	10	11
NCAT	N_c	5.0	→	→	→	→	N/A	→	→	5.0	→	→
PCAT(I)	P_i											
I = 1		0.683	→	0.610	0.683	→	N/A	→	→	0.683	→	→
2		0.053	→	0.030	0.053	→	N/A	→	→	0.053	→	→
3		0.022	→	0.091	0.022	→	N/A	→	→	0.022	→	→
4		0.044	→	0.015	0.044	→	N/A	→	→	0.044	→	→
5		0.005	→	0.003	0.005	→	N/A	→	→	0.005	→	→
THFM(I)	$\bar{\theta}_{f_i}$											
I = 1		-1.19	→	-1.37	0.17	→	N/A	→	→	-1.19	→	0.17
2		5.0	→	→	→	→	N/A	→	→	5.0	→	→
3		-12.0	→	→	→	→	N/A	→	→	-12.0	→	→
4		-18.0	→	→	→	→	N/A	→	→	-18.0	→	→
5		-45.0	→	→	→	→	N/A	→	→	-45.0	→	→
THFS(I)	$\sigma_{\theta_{f_i}}$											
I = 1		1.69	→	1.54	2.12	→	N/A	→	→	1.69	→	2.12
2		0.0	→	→	→	→	N/A	→	→	0.0	→	→
3		0.0	→	→	→	→	N/A	→	→	0.0	→	→
4		0.0	→	→	→	→	N/A	→	→	0.0	→	→
5		0.0	→	→	→	→	N/A	→	→	0.0	→	→
PSFM(I)	$\bar{\psi}_{f_i}$											
I = 1		0.71	→	1.08	-0.26	→	N/A	→	→	0.71	→	-0.26
2		40.0	→	→	→	→	N/A	→	→	40.0	→	→
3		-52.0	→	→	→	→	N/A	→	→	-52.0	→	→
4		0.0	→	→	→	→	N/A	→	→	0.0	→	→
5		45.0	→	→	→	→	N/A	→	→	45.0	→	→

TABLE F-11. (continued)

Mnemonic	Parameter	Scenario: (Night) 1	2	3	4	5	6	7	8	9	10	11
PSFS(I)	$\sigma_{\psi_{f_i}}$											
I = 1		2.11	→	→	2.92	→	N/A	→	→	2.11	→	2.92
2		0.0	→	→	→	→	N/A	→	→	0.0	→	→
3		0.0	→	→	→	→	N/A	→	→	0.0	→	→
4		0.0	→	→	→	→	N/A	→	→	0.0	→	→
5		0.0	→	→	→	→	N/A	→	→	0.0	→	→
TAUFM(I)	$\overline{\tau}_{f_i}$											
I = 1		0.76	→	1.36	→	→	N/A	→	→	1.64	→	→
2		0.73	→	0.59	0.73	→	N/A	→	→	0.73	→	→
3		1.08	→	0.72	1.08	→	N/A	→	→	1.08	→	→
4		0.68	→	0.61	0.68	→	N/A	→	→	0.68	→	→
5		1.44	→	→	→	→	N/A	→	→	1.44	→	→
TAUFS(I)	$\sigma_{\tau_{f_i}}$											
I = 1		1.06	→	1.68	→	→	N/A	→	→	2.08	→	→
2		0.33	→	0.35	0.33	→	N/A	→	→	0.33	→	→
3		0.72	→	0.39	0.72	→	N/A	→	→	0.72	→	→
4		0.27	→	0.25	0.27	→	N/A	→	→	0.27	→	→
5		0.56	→	→	→	→	N/A	→	→	0.56	→	→
NGLARE	N_g	2.0	→	→	→	→	N/A	→	→	2.0	→	→
EG(I)	E_{g_i}											
I = 1		0.0	→	→	→	→	N/A	→	→	0.0	→	→
2		0.0	→	→	→	→	N/A	→	→	0.0	→	→
THG(I)	θ_{g_i}											
I = 1		0.0	→	→	→	→	N/A	→	→	0.0	→	→
2		0.0	→	→	→	→	N/A	→	→	0.0	→	→

TABLE F-11. (concluded)

Mnemonic	Parameter	Scenario: (Night) 1	2	3	4	5	6	7	8	9	10	11
PSG(I)	ψ_{g_i}											
I = 1		0.0	→	→	→	→	N/A	→	→	0.0	→	→
2		0.0	→	→	→	→	N/A	→	→	0.0	→	→

TABLE F-12. NOMINAL TABULAR DATA FOR INTERSECTING VEHICLE LINE-OF-SIGHT PROBABILITY IN DRIVER EVENT-DETECTION MODEL: "DAY 1" AND "DAY 2" CONDITIONS

Mnemonic	Variable	Scenarios 6, 7, and 8 only; day only
PMERG	P_{merg}	

ψ_o (from, ≤)	ψ_o (to, <)	P_{merg}
-90	-85	1.0
-85	-80	1.0
-80	-75	1.0
-75	-70	1.0
-70	-65	1.0
-65	-60	1.0
-60	-55	1.0
-55	-50	1.0
-50	-45	1.0
-45	-40	1.0
-40	-35	0.5
-35	-30	0.5
-30	-25	1.0
-25	-20	1.0
-20	-15	1.0
-15	-10	1.0
-10	- 5	1.0
- 5	- 0	1.0
0	5	1.0
5	10	1.0
10	15	1.0
15	20	1.0
20	25	1.0
25	30	0.5
30	35	0.25
35	40	0.25
40	45	0.25
45	50	0.5
50	55	1.0
55	60	1.0
60	65	1.0
65	70	1.0
70	75	0.5
75	80	1.0
80	85	1.0
85	90	1.0

TABLE F-13. NOMINAL TABULAR DATA FOR SUBJECT-VEHICLE HEADLAMPS IN DRIVER EVENT-DETECTION MODEL: "NIGHT" CONDITION

(Scenarios 9, 10, and 11 only; night only)

Mnemonic	Variable
ISVO, ISVB	I_{sv_o}, I_{sv_b}

γ_v	$\gamma_h = 0$
4	1000.0*
3	1000.0
2	1000.0
1	1300.0
0	3000.0
-1	11000.0
-2	12000.0
-3	7900.0
-4	4000.0
-5	1800.0
-6	1000.0

*I_{sv_o} and I_{sv_b} interpolated from table values

TABLE F-14. NOMINAL TABULAR DATA FOR ONCOMING-VEHICLE HEADLAMPS IN DRIVER EVENT-DETECTION MODEL: "NIGHT" CONDITION

Mnemonic	Variable
INV	I_{nv}

(Scenarios 4, 5, and 11 only; night only)

γ_v \ γ_h	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
4	1000.*	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
3	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
2	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.
1	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1000.	1300.
0	1900.	1900.	1900.	1900.	1900.	1900.	1900.	1900.	1900.	1900.	3000.
-1	3500.	3500.	3500.	3500.	3800.	3900.	4050.	4200.	5200.	6500.	11000.

* I_{nv} interpolated from table values

TABLE F-15. NOMINAL TABULAR DATA FOR FOVEAL CONTRAST THRESHOLDS IN DRIVER EVENT-DETECTION MODEL

Mnemonic	Variable
CFOVO, CFOVL	C_{fov_o}, C_{fov_ℓ}

(All scenarios)

		$\log_{10} a_o$, $\log_{10} a_\ell$						
		-3.66	-2.66	-1.66	-0.66	0.34	1.34	2.34
$\log_{10}(L_a + L_v)$	-3.00	2.98*	2.00	1.27	0.81	0.62	0.46	0.37
	-2.00	2.09	1.12	0.37	0.01	-0.20	-0.33	-0.39
	-1.00	1.37	0.42	-0.29	-0.68	-0.87	-0.96	-1.03
	0.0	0.82	-0.14	-0.78	-1.08	-1.25	-1.34	-1.37
	1.00	0.42	-0.49	-0.98	-1.22	-1.34	-1.41	-1.44
	2.00	0.11	-0.73	-1.13	-1.30	-1.39	-1.45	-1.47
	3.00	-0.03	-0.84	-1.20	-1.35	-1.42	-1.47	-1.49
	4.00	-0.10	-0.90	-1.24	-1.38	-1.44	-1.48	-1.50

*$\log_{10} C_{fov_o}$, $\log_{10} C_{fov_\ell}$ interpolated from table values

TABLE F-16. NOMINAL TABULAR DATA FOR PERIPHERAL CONTRAST THRESHOLDS IN DRIVER EVENT-DETECTION MODEL

Mnemonic	Variable
CPERO, CPERL	C_{per_o}, C_{per_ℓ}

All Scenarios

	$\log_{10} a_o > \log_{10} a_\ell$						
α_o, α_ℓ	-3.66	-2.66	-1.66	-0.66	0.34	1.34	2.34
0.0	0.0*	0.0	0.0	0.0	0.0	0.0	0.0
1.00	0.25	0.21	0.12	0.08	0.05	0.02	0.0
2.00	0.43	0.39	0.21	0.13	0.09	0.05	0.01
3.00	0.56	0.51	0.28	0.19	0.13	0.07	0.02
4.00	0.66	0.61	0.35	0.24	0.17	0.10	0.03
5.00	0.74	0.69	0.41	0.29	0.22	0.14	0.06
6.00	0.81	0.76	0.47	0.34	0.26	0.18	0.09
7.00	0.87	0.81	0.52	0.39	0.30	0.21	0.12
8.00	0.92	0.86	0.58	0.44	0.34	0.25	0.15
9.00	0.97	0.91	0.63	0.48	0.38	0.28	0.18
10.00	1.02	0.97	0.68	0.52	0.42	0.32	0.22
15.00	1.25	1.20	0.91	0.74	0.63	0.51	0.39
20.00	1.49	1.44	1.15	0.97	0.84	0.70	0.56
25.00	1.73	1.68	1.38	1.19	1.04	0.89	0.74
30.00	1.96	1.91	1.61	1.42	1.25	1.08	0.91
35.00	2.20	2.14	1.85	1.63	1.45	1.27	1.09
40.00	2.44	2.37	2.08	1.85	1.66	1.46	1.26
45.00	2.67	2.61	2.32	2.07	1.86	1.65	1.44
50.00	2.91	2.84	2.55	2.30	2.07	1.84	1.61
55.00	3.14	3.08	2.79	2.52	2.27	2.03	1.79
60.00	3.38	3.31	3.02	2.72	2.48	2.22	1.96
65.00	3.62	3.54	3.25	2.96	2.69	2.41	2.13
70.00	3.85	3.78	3.49	3.18	2.89	2.60	2.31
75.00	4.09	4.01	3.72	3.41	3.10	2.79	2.48
80.00	4.32	4.25	3.96	3.63	3.30	2.98	2.66
85.00	4.56	4.48	4.19	3.85	3.51	3.17	2.83
90.00	4.80	4.71	4.42	4.07	3.72	3.36	3.00

*$\log_{10}$ $Cper_o$, $\log_{10}$ $Cper_\ell$ interpolated from table values

APPENDIX G

BASIS FOR NOMINAL DATA

The basis for the nominal data in Appendix F is presented below in the same order as the sample output file list shown in Appendix C, Figure C-6. Identification of parameters by their mnemonic notation facilitates cross-reference with Figure C-6 and the data tables in Appendix F. Parameter values having no basis for estimate or considered to be arbitrary values are indicated as such.

SUBJECT VEHICLE INITIAL CONDITION PARAMETERS

Initial SV longitudinal velocity (UH0) is assumed to be the same as other vehicles in traffic. The traffic speed in scenarios most representative of freeway or open-road driving conditions is arbitrarily set at 55 mph. In other scenarios more representative of urban driving conditions, vehicle speeds are initialized at 40 mph.

The remaining initial conditions are all nominally zero for a vehicle traveling at constant forward velocity on straight and smooth roadway. Longitudinal position (X0) is used only for vehicle checkout (scenario 0). It is not used for any of scenarios 1-11 since SV position is determined by scenario definition parameters as discussed in Section 7. The rest of the parameters are useful primarily for vehicle checkout. However, they can be made random variables if the user desires. Under normal driving situations these initial conditions have little if any effect on collision probability.

SUBJECT VEHICLE MODEL PARAMETERS

Model parameters for the subject vehicle (a 1971 Dodge Coronet) are taken primarily from Reference 1. This particular vehicle was selected because data were readily available for it. Table G-1 shows sources of data for each vehicle parameter. The first column gives the parameter; the second column gives an expression from which data were derived in Reference 1 (except where otherwise noted). Column three shows the scale factor used to convert these data to the proper units for the DRIVEM simulation (that is, conversion from inches to feet). The last two columns give the nominal value and units used in the DRIVEM simulation.

TABLE G-1. DATA BASIS FOR SUBJECT VEHICLE PARAMETERS

DRIVEM Variable	Derived from Reference 1	Scale Factor	Value	Units
WEIGHT	$W = (M_S + M_{uF} + M_{uR})\, g$	x 12	3771.0	lb
IXX	I_x	÷ 12	313 .0	$ft\text{-}lb\text{-}sec^2$
IYY	I_y	÷ 12	1917.0	$ft\text{-}lb\text{-}sec^2$
IZZ	$I_{zz} = I_z + M_{uF}(a^2 + \frac{T_F^2}{4}) + M_{uR}\, b^2$	÷ 12	2405.0	$ft\text{-}lb\text{-}sec^2$
DF	a	÷ 12	4.11	ft
DR	b	÷ 12	5.73	ft
TF	$T_{F/2}$	÷ 12	2.49	ft
TR	$T_{R/2}$	÷ 12	2.58	ft
ZF	Z_F	÷ 12	0.90	ft
ZR	Z_R	÷ 12	0.90	ft
HF	R_W	÷ 12	1.10	ft
HR	R_W	÷ 12	1.10	ft
KF	K_F	x 12	1260.0	lb/ft
KR	K_R	x 12	1440.0	lb/ft
CF	C_F	x 12	52.0	lb/ft/sec
CR	C_R	x 12	100.0	lb/ft/sec
MUXF	$\mu_{PF} = P_{BF1} + P_{BF2}\, W_f$ (Note 1)		0.85	
MUXR	$\mu_{PR} = P_{BR1} + P_{BR2}\, W_r$ (Note 1)		0.88	
MUYF	$\mu_{yF} = B_1 W_f + B_3 + B_4 W_f^2$ (Note 1)		0.96	
MUYR	$\mu_{yR} = RB_1 W_r + RB_3 + RB_4 W_r^2$ (Note 1)		1.02	
BETASF	Note 2		20.0	deg
BETASR	Note 2		17.0	deg
SNR	S_{NSO}/S_{NT}		1.0	
KSW	$1/N_G$		0.07	
KBF	Note 3		0.6	
KBR	Note 3		0.4	
KSC	Note 4		0.0	ft-lb/ft/se
UCMD	Note 4		0.0	ft/sec
TDMAX	Note 4		0.0	ft-lb

Notes:

1. $W_f = \frac{W}{2}\,\frac{b}{a+b} = 1098$ lb, $W_r = \frac{W}{2}\,\frac{a}{a+b} = 788$ lb

2. Taken from plot of Dodge Coronet tire characteristics (Reference 2, p. 9).

3. Typical brake torque distribution (Reference 3, p. 351).

4. Not used for normal DRIVEM applications.

Most of the items in Table G-1 were taken directly from Reference 1 after scaling to the proper units, but some were computed from other quantities. Vehicle weight (WEIGHT) was computed by multiplying gravity (g) by the sum of the sprung mass (M_s) and the two unsprung masses (M_{uF}, M_{uR}). Moment of inertia about the z body axis (IZZ) is taken to be the sum of the inertia of the sprung mass (I_z) plus that due to the unsprung masses. Longitudinal tire coefficients of friction (MUXF, MUXR) are defined as a constant term plus a term linear in the normal force. Lateral tire coefficients of friction (MUYF, MUYR) include constant, plus linear, plus quadratic terms in normal force as defined in Reference 1. Tire sideslip saturation angles (BETASF, BETASR) represent measured tire characteristics for the Dodge Coronet tire (Reference 2). Brake torque distribution assumes typical values of 60 percent front and 40 percent rear (Reference 3). The last three parameters (KSC, UCMD, TDMAX) are not used for normal DRIVEM applications so their nominal values are zero.

DRIVER CONTROL MODEL PARAMETERS

Driver control model parameters are separated into two groups, as was done in Section 11: open-loop control parameters and closed-loop control parameters. One parameter (MANDEC) is not used for normal DRIVEM applications and is nominally set to zero. It specifies the driver's evasive maneuver decision when the maneuver decision model is bypassed (MSCEN = 0). Thresholds for longitudinal velocity error (VETH) and lateral position error (YETH) of 2 ft/sec and 2 ft, respectively, define the conditions above which open-loop control is initiated. Closed-loop control is resumed when errors first fall below these thresholds.

Open-Loop Control Parameters

These parameters describe the driver's open-loop braking and steering characteristics. The nominal rate limit for normalized brake inputs (ABR) is set to zero, which indicates that pure step brake inputs are used. The nominal amplitude limits for driver-generated normalized brake step inputs (ABSTB, ABSTC) are 0.75 and 0.60, respectively. These produce deceleration levels of ~ 0.75 g's and ~ 0.65 g's, respectively. Reference 4 suggests that 0.75 g's is about the maximum deceleration rate that an experienced driver, who is familiar with his automobile, will generate in a braking maneuver. The brake amplitude limit is reduced from 0.75 to 0.60 for the combined braking and steering maneuver to avoid saturation of tire forces. The choice of the period for sinusoidal steering wheel inputs (TSW) is based on automobile simulator experience

(Reference 5), which suggests a typical period of 1 sec for a rapid lane change maneuve
Values of 1.1 and 1.5 sec are chosen for scenarios at 55 and 40 mph, respectively, so t
spatial duration of the maneuver is the same in each case. Peak steering amplitudes (ASWS, ASWC) of 90 degrees are selected to give an (open-loop) lane change of approxi
12 ft (the assumed lane width).

Closed-Loop Control Parameters

These parameters describe the driver's closed-loop braking and steering characteristic
Describing function model parameters (TR, TAUP, WC) are set at 0.2 sec, 3.0 sec, ar
3.5 rad/sec based on typical results in References 5 through 10. Parameter values for steering wheel amplitude and rate limits (SWMAX, SWRMAX) of 720 degrees and 600 deg/sec are assumed. These limit steering inputs for closed-loop steering control.

SCENARIO DEFINITION PARAMETERS

Initial Vehicle Headways

A value of 1.0 second was selected for initial time headway between SV and OV. This value is representative of short headways in traffic (Reference 11) and was anticipated to be within a range yielding accident probabilities [P(A)] of 0 < P(A) < 1 in the scenario
simulated. A 1 sec time headway corresponds to space (distance) headways of HOV = 5
feet and HOV = 81 feet for the nominal 40 mph and 55 mph traffic speeds assumed. Headways between object and lead vehicles (HLV) in scenarios 2 and 5 are arbitrarily set to the same values.

Initial OV, LV, and NV Velocities

Initial velocities of other vehicles (UOV0, ULV0, and UNV0) are set the same as initial SV velocity, UH0. Note that initial OV velocity in scenarios 6, 7, and 8 is not a parameter. Velocity of OV in these scenarios is calculated such that the two vehicles will collide unless SV takes evasive action.

OV and LV Deceleration Levels

The value of OV deceleration (DOVG = 0.5g) is typical of deceleration levels generated by drivers in a controlled braking maneuver (Reference 4). Lead-vehicle deceleration

(DLVG) in scenarios 2 and 5 is arbitrarily set to half the above value to minimize the chance of OV "colliding" with LV. This collision is not explicitly accounted for in the model.

Headways in Oncoming Traffic

A minimum time headway of 0.5 seconds is assumed. This corresponds to minimum space or distance headways in oncoming traffic of HNVMIN = 29 feet at 40 mph and HNVMIN = 40 feet at 55 mph. Mean distance headway in oncoming traffic, HNVAVE = 1056 feet, is based on a low-density traffic condition of five vehicles per mile. If steering maneuvers are allowed in the decision model (PS0 > 0 or PB0 + PS0 < 1), the likelihood that the simulated driver will actually initiate a steering maneuver is a function of oncoming traffic density. Increasing oncoming traffic density (lower numeric value of HNVAVE) would increase the probability of a brake-only response since the driver is not allowed to steer into an oncoming vehicle (NV).

The above nominal values are used to generate a sequence of NVs with random headways (see Section 7). In this case, the value of parameter DISTNS should equal zero (see discussion below). If a single NV at specified distance DISTNS is needed, parameters HNVMIN and HNVAVE should be set to zero.

Collision Point Distance and OV Bearing

Initial SV distance from the potential point of collision in scenarios 6, 7, and 8 (DISTSO = 500 ft) is equivalent to 6.2 and 8.5 seconds, respectively, at the nominal traffic speeds of 40 and 55 mph. These time intervals were considered sufficient for detection and evasive action if line of sight to OV is not obscured. Parameter PSIB, defining initial OV bearing relative to SV in scenarios 6, 7, and 8, is assigned an arbitrary value of 45 degrees. These scenarios are designed primarily to evaluate effects of line-of-sight obstructions on detection of laterally moving vehicles. Appropriate values of PSIB would vary depending on other variables being evaluated (for example, center-mirror or A-pillar width or placement).

Initial Distance to Oncoming Vehicle

The nominal condition for oncoming traffic is a sequence of vehicles with random headways determined by non-zero values of HNVMIN and HNVAVE (see above discussion of these parameters). For this condition, parameter DISTNS should equal zero. By setting DISTNS to some specified distance and setting HNVMIN = HNVAVE = 0, a single NV is generated at the distance specified. This option would be useful for evaluating effects of oncoming headlamp glare under controlled conditions.

Lane Width

A lane width of 12 feet is typical of modern freeway design (Reference 11). Widths of fr eight to 11 feet would be more appropriate to represent other types of roadway.

Detection and Response Delays

When the event detection model is not simulated (MDET = 0), TAUD substitutes a user-definable time interval representing a lumped approximation of delays due to detection and/or decision making. Parameter TAUOVD serves a similar function by determining the OV driver's delay in response to LV deceleration. Nominal values of 1.5 seconds for both parameters approximate a combined detection and decision delay. This value is near the average delay that would result from detection-model simulation, with event detection occurring on the initial visual fixation.

MANEUVER DECISION MODEL PARAMETERS

Adjacent Vehicle Length

The projected-1985 vehicle mix based on proportion of miles traveled is approximately 75 percent passenger cars and 25 percent trucks (Reference 12). Assuming average car and truck lengths of 15 feet and 35 feet, respectively, average vehicle length in adjacent traffic (LAV) is nominally 20 feet.

Headways in Adjacent Traffic

A minimum time headway of 0.5 seconds is assumed. This corresponds to a minimum space (distance) headway of HAVMIN = 40 feet at 55 mph. Mean distance headway of HAVAVE = 176 feet is based on a moderate traffic density (Reference 11) of 30 vehicles per mile.

Safe Maneuvering Regions

The combined lengths of LF + LR = 30 feet effectively define a gap-acceptance threshold for maneuvering into adjacent-lane unidirectional traffic. No basis was found for estimating gap acceptance in emergency maneuvering situations similar to those simulated.

Maneuver Decision Probabilities

A priori maneuver-decision probabilities (PB0 and PS0) are based on two data sources: 1) surprise intrusion tests involving 33 unalerted drivers (Reference 4), and 2) analyses of evasive responses attempted by 157 accident-involved drivers in situations most similar to DRIVEM scenarios (Reference 13). Proportions of maneuver responses obtained from further reduction and analysis of data in these sources are summarized below.

Brake Only	Steer Only	Combined Brake-Steer	
0.303	0.121	0.576	(derived from Reference 4)
0.497	0.038	0.065	(derived from Reference 13)
0.400	0.080	0.520	(average)

The above average values are applied to define PB0 = 0.400 and PS0 = 0.080. Probability of combined brake and steer is determined in the model by 1 - PB0 - PS0, which in this case is 0.520.

Awareness of Adjacent Traffic

No basis was found for estimating the driver's a priori awareness (PA) of the presence of vehicles in adjacent-lane regions L2 and R2 (see Section 9). This probability is anticipated to be a function of mirror and vehicle structural design, as well as driver tendencies to monitor traffic in these regions via mirror or direct glances. The value of PA is arbitrarily set to 0.5.

Maneuver Time and Distance Thresholds

No basis was found for estimating the threshold for time available (TTHRSH) above which a driver is willing to verify presence of vehicles in adjacent unidirectional traffic lanes prior to maneuvering. The value of this threshold is arbitrarily set to 1.0 second. The values of distance threshold DTHRSH for lateral maneuvering in the presence of oncoming traffic are estimated from a study by Crawford (Reference 14). An assumption required is that the threshold for a pass/no-pass decision from this referenced study is a reasonable approximation of a similar threshold for lateral maneuvering in emergency situations. Results obtained by Crawford are approximated by

DTHRSH = 7.2 (closing velocity) + 230.4

with closing velocity in ft/sec. Closing velocities of SV and NV vary with nominal vehicle speeds defined for each scenario. For vehicle speeds of 40 and 55 mph, closing velocities are 117.4 and 161.4 ft/sec, respectively. With substitution of these velocities in the above expression, corresponding values of DTHRSH are 1076 and 1392 feet.

Time to Look

Direct glances to adjacent-lane regions R2 or L2 (see Section 9) are assumed to require between 40 and 60 degrees of head rotation. A study by Robinson, et al. (Reference 15) indicates that a quick glance to one side would require about 0.6 sec (including 0.2 sec dwell time). Allowing for the possible need to glance to both sides (approximately 1.2 sec total), the nominal value of TLOOK is set at 1.0 sec.

EVENT DETECTION MODEL PARAMETERS

Illumination from Sky and Sun

Published data in the IES Lighting Handbook (Reference 16) provided nominal values for parameters ESKY and ESUN. A latitude of 38 degrees north is representative of the continental United States. For arbitrarily selected periods of mid-March or September, during mid-morning and afternoon, the sun at this latitude is about 45 degrees above the horizon.

Two sets of nominal data are defined. Data for "day 1" assumes a clear day with the sun directly ahead of the SV at 45 degrees above the horizon. "Day 2" is the same except that the sun is located directly behind the SV.

ESKY is the illuminance produced by the sky on a vertical surface whose outward normal vector is directed toward the SV driver. Nominal values of ESKY are from Figure 7-13 in Reference 16. On day 1, since the sun is in front of the SV, the outward normal vector toward SV is also directed away from the sun and thus is shadowed from the brightest area of sky. The resulting illuminance from a clear summer sky is

ESKY = 400 ft-cd. Day 2 has a higher value of illuminance (ESKY = 1480 ft-cd) since the outward normal vector from a vertical surface toward the SV is also pointed toward a brighter sky area surrounding the sun.

ESUN includes illuminance produced only by the sun on a surface whose outward normal vector is directed at the sun (that is, a surface oriented normal to the sun's rays). During the above calendar periods and with sun altitude of 45 degrees above the horizon, ESUN is approximately 8000 ft-cd for both day 1 and day 2 conditions.

Sun Angles of Incidence

In general, the angle between an outward normal vector from any surface and a vector to the sun (that is, either BSUNO or BSUNB) can be determined by

$$\beta_{sun} = \cos^{-1} [\sin \theta_s \sin \theta_n \cos (\phi_s + \phi_n) + \cos \theta_s \cos \theta_n]$$

where a positive x-axis is directed parallel to the SV and

$\hat{s}$ = unit normal vector from origin to the sun

$\hat{n}$ = unit outward normal vector from the surface in question

θ_s = zenith angle between an upward vertical line and $\hat{s}$ (deg)

θ_n = zenith angle between an upward vertical line and $\hat{n}$ (deg)

ϕ_s = azimuth angle in a horizontal plane from the x-axis to $\hat{s}$ (deg)

ϕ_n = azimuth angle in a horizontal plane from the x-axis to $\hat{n}$ (deg)

Figures G-1 and G-2 illustrate this geometry. The parameter BSUNO is the angle between an outward normal vector from the relevant object surface (as viewed from the SV) and a vector directed at the sun. All object surfaces for which BSUNO is applicable (see Appendix F, Tables F-6 and F-7) are assumed to be vertically oriented. With the exception of the detectable object in scenario 6 (side of merging OV), relevant surfaces are facing away from the sun under day 1 conditions and facing toward the sun under day 2 conditions. The ramp lane with approaching OV in scenario 6 is assumed to merge with the SV's traffic lane at an angle of 30 degrees (see Section 7). In terms of the above expression, the horizontal angle ϕ_n defined by the side of this merging vehicle is ϕ_n = -120 deg.

BSUNB is the angle between the relevant object's background and a vector directed at the sun. As described in Section 8, the daytime background in scenarios 1 through 5

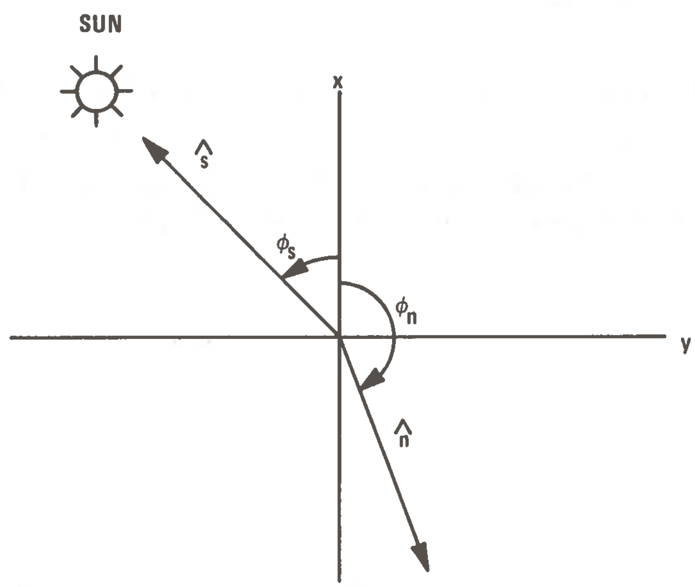

FIGURE G-1. PLAN VIEW SHOWING ANGLES 0_s and 0_n

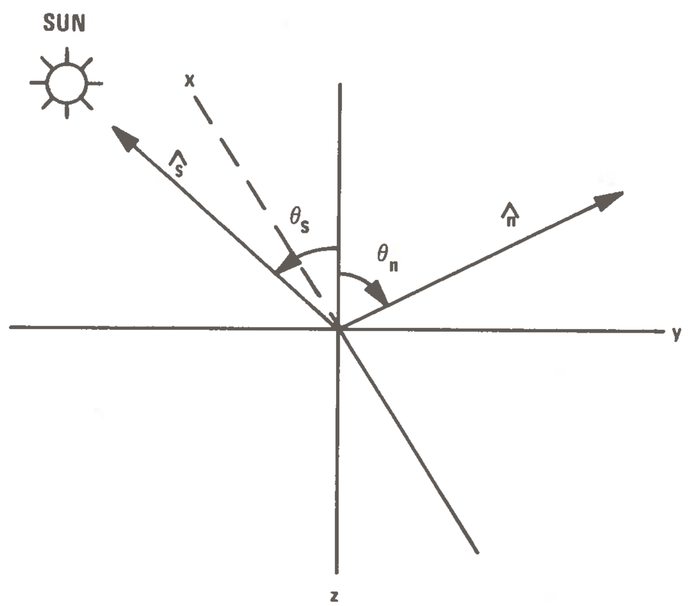

FIGURE G-2. PERSPECTIVE VIEW SHOWING ANGLES θ_s AND θ_n

is assumed to be a (vertically oriented) tail/brakelamp lens with lamps not illuminated. In all other scenarios, a horizontal ground plane is assumed for the relevant background.

Nominal values of BSUNO and BSUNB are calculated from the above general expression, with the limitation that calculated values greater than 90 degrees are set equal to 90 degrees. In general, when $\beta_{sun} \geq 90$ deg, the illuminance on the surface due to direct sunlight is zero. If data other than current nominal values of these parameters are calculated, the preceding limit on calculated values is unnecessary since an equivalent limit has been built into the program. For example, in Section 8, Equation (8-12), cos BSUNO = 0 when BSUNO > 90 deg.

Sky and Surround Luminances

Figure 25 in Reference 17 provided nominal data for sky and surround luminance parameters LSKY and LSUR under daytime conditions similar to those of day 1 and day 2. The following luminance measurements were made in the general area of Phoenix, Arizona, during mid-afternoon with the sun at 54 degrees above the horizon.

- Azimuth toward the sun (day 1)
  - sky above horizon = 2693 ft-L
  - terrain below horizon = 2108 ft-L
- Azimuth away from the sun (day 2)
  - sky above horizon = 1673 ft-L
  - terrain below horizon = 1752 ft-L

Nominal values of LSKY are based on rounding the above horizon sky luminance measures to 2700 and 1700 ft-L for day 1 and day 2, respectively. Assuming a mean visual fixation point in the vicinity of the horizon, values of surround luminance LSUR are (2693 + 2108)/2 $\simeq$ 2400 ft-L for day 1 and (1673 + 1752)/2 $\simeq$ 1700 ft-L for day 2.

The value of LSKY = 0.1 ft-L for the night condition assumes a horizon sky luminance characteristic of deep twilight (Reference 16). Figure 9 in Reference 18 illustrates the combined types of data (mean fixation point relative to headlamp isoluminance contours) needed to approximate LSUR at night. The value of LSUR - 0.3 ft-L was estimated from this source.

Object Photometric Values

Parameters discussed here are object reflectances (RO), illuminances (EO), and lumino intensities (IO). Reflectance can vary over a wide range approaching zero or unity depending on factors such as surface texture, lightness, viewing angle, and the angle of incident illumination (Reference 16). Object reflectance for scenarios 6, 7, and 8 (side of laterally moving vehicle) and scenarios 10 and 11 (object on roadway) is assigned an arbitrary nominal value of RO = 0.5. This value is typical of a medium grey or pastel (low saturation) color. The value of RO = 0.12 for scenario 9 is a representative reflectance for summer clothing (Reference 19).

Object illuminance (EO) is used only in calculating visibility of objects on roadway (scenarios 9, 10, and 11) at night; it refers to illumination produced by stationary lighting sources. Nominal data assume that no light sources of this type are present. Therefore, EO = 0 ft-cd.

The object luminous intensity parameter IO applies to the "on" state of object and lead vehicle brakelamps (stoplamps) in scenarios 1 through 5. The nominal value of IO = 70 cd is based on SAE Standard J586c, minimum design candlepower requirements for single-compartment stoplamps (Reference 20). Luminous intensity in the general direction of the SV driver was approximated by an average value of the following six test points.

Test Point	Luminous Intensity (cd)
5U-5L	50
5U-V	70
5U-5R	50
H-5L	80
H-V	80
H-5R	80
	mean = 68.3 $\simeq$ 70 cd

It may be noted that SAE Recommended Practice J186 (Reference 20) provides recommended luminous intensities for supplemental high mounted stoplamps. These intensities are all 15 cd for the above six test points.

Background Photometric Values

Parameters of object backgrounds are reflectance (RB), illuminance (EB), and luminous intensity (IB). As indicated in Section 8, brakelamps and taillamps are assumed to be colocated with a common lens. For scenarios 1 through 5, this lens is treated as the background in calculations of brakelamp onset detectability. No basis was found for estimating lens reflectance under daytime conditions when neither brakelamp or taillamp are illuminated. Lens reflectance for this case is estimated at RB = 0.2. This lens is treated as a background with luminous intensity (IB) of a taillamp under nighttime conditions. The nominal value of IB is based on SAE Standard J585d, minimum design candlepower requirements for single-compartment taillamps (Reference 20). Luminous intensities of the same testpoints identified above for stoplamps average 1.73 cd for taillamps. This value was rounded to IB = 2.0 cd.

All backgrounds in scenarios 6 through 11 are assumed to be a horizontal ground plane characterized by reflectance RB. Grass adjacent to the roadway is arbitrarily assumed as the object background in scenarios 6, 7, and 8. In scenarios 9, 10, and 11, background for object line of sight below the horizon is taken to be a concrete road surface. Nominal reflectances of grass and concrete for the day 1 and day 2 illumination conditions are from Table 3.2 in Reference 21. Reflectances of these backgrounds at night at shallow angles associated with headlight illumination were approximated from retro-reflectance data in Reference 19.

Background illuminance (EB) is used only in calculating visibility of objects on roadway (scenarios 9, 10, and 11) at night, and refers to background illumination produced by stationary lighting sources. Nominal data assume that no light sources of this type are present. Therefore, EB = 0 ft-cd.

Windshield Transmittance

Two parameters, T and KL, account for transmittance of glass surfaces between the SV driver and objects or events to be detected. The nominal value of T = 0.7 is approximated from measurements by Dunn (Reference 22) which indicate a tinted-windshield transmittance of 0.71 using a CIA Illuminant A source (blackbody at 2854 deg Kelvin) at a 45-degree angle of incidence.

Parameter KL is a scale factor applied in scenarios 2 and 5 to account for reduction in LV brakelamp and associated background luminance due to the two additional intervening glass surfaces (OV front and rear windows). The nominal value of KL = 0.5 assumes a combined transmittance for these surfaces of 0.5.

It should be noted that the value of parameter (T) can be adjusted to account for transmittance of sunglasses. Also, Reference 22 contains a variety of other transmittance data for different types of automobile glass, sunglasses, angles of incidence (effectively, glass tilt angle), and light source spectra.

Object Dimensions

A four-inch square brakelamp lens was assumed as the detectable object (event) in scenarios 1 through 5. Vertical and horizontal object dimensions for these scenarios are therefore VO = HO = 0.33 feet. Detectable objects in scenarios 6, 7, and 8 are nominally the side surfaces of laterally moving vehicles. These dimensions are approximated by VO = 4 feet and HO = 14 feet. A vehicle length of 14 feet is typical of current passenger cars in the 2500-3000 pound weight class (see subsection below on Collision-Determination Algorithm parameters). Object dimensions in scenario 9 approximate the profile view of a human torso. Dimensions of objects on roadway in scenarios 10 and 11 are purely arbitrary, and can assume any reasonable values. Specific types of objects on roadway were not assumed in selecting nominal values for object dimensions and reflectance.

Line of Sight to LV Brakelamps

No basis was found for estimating the probability of a clear line of sight through OV windows to LV brakelamps. The nominal value of PLITE = 0.2 is considered a reasonabl estimate for the nominal SV-to-OV and OV-to-LV initial headways assumed. Actual values could be expected to vary over a considerable range due to factors such as OV structural design and passenger loading as well as SV driver eye height and LV brakelamp location.

Detectable Headway Change

The parameters HRTH and HPER define a threshold for driver detection of a change in headway when OV decelerates. This model provision accomodates the possibility that for certain combinations of brakelamps luminous intensity and ambient illumination, brakelamp onset may in fact not be detectable.

Parameter JRTH defines a threshold for detecting headway change. The value, HRTH = 0.12, is based on a study by Mortimer (Reference 23) who concluded that the ratio of detectable headway change (ΔH) to initial headway (H) is relatively constant over a range of vehicle speeds and headways. The median value of this ratio (corresponding to threshold level detection performance) was found to be $\Delta H/H = 0.12$. Parameter HPER is essentially an acuity threshold for peripherally detecting that a change in OV angular subtense (decreased headway) has occurred. No basis was found to estimate the value of this parameter for an unalerted driver.

"Frequency-of-Seeing" Distribution

Parameter SIGC is the standard deviation of the normalized Gaussian distribution applied to characterize change in detection probability due to variations in object/background relative contrast. The value SIGC = 0.5 is based on laboratory results (Reference 24) indicating $\sigma = 0.485$ for a stimulus duration of one second (analogous to a fixation duration in DRIVEM) and implications by Davies (Reference 25) that this distribution would have greater variability under more real-world conditions.

Time Constants for Transient Adaptation

Analyses of experimental data reported by Spencer (Reference 26) indicate that short-term effects of visual adaptation from one ambient luminance to another (that is, one visual fixation to another in DRIVEM) can be approximated by an exponential function. While these analyses suggest the possibility of a different time constant depending on the direction of luminance change, Spencer recommended that a single average value be applied pending further work. Parameters KV1 and KV2 are reciprocals of the exponential time constants for increasing and decreasing luminence, respectively, and are both assigned nominal values of 6.7 (sec^{-1}) based on Spencer's preliminary recommendations. The two parameters are included in the model to cover the possibility that further work may demonstrate the need for different time constants.

Glare Source Minimum Eccentricity Angle

Parameter ALPHMIN limits minimum glare-source eccentricity angle to a value greater than zero to avoid a calculated value of infinite veiling luminance (see Equations 8-26 and 8-29 in Section 8). No basis was found for estimating the value of this parameter. Since foveal vision subtends an angle of approximately 1.5 degrees, a nominal value of ALPHMIN = 0.5 is assumed to allow glare sources to appear in foveal view but not directly in the center thereof.

Eye, Light, and Object Heights Above Roadway

Nominal mid-point heights above roadway of driver eye position (HEYE), headlamps (HLITE), and brakelamps (HOBJ) are based on measurements taken from a sample of 10 domestic and foreign automobiles, with seated eye height approximating that of a fiftieth percentile male (Reference 27). In scenario 9, HOBJ = 3.5 feet corresponds approximately to the elbow height of a standing fiftieth percentile male (Reference 27). From the object vertical dimension (VO = 3.0 feet) given earlier for this scenario, the detectable object in scenario 9 (human torso) is therefore assumed to extend from 2.0 to 5.0 feet above the roadway. Detectable objects in scenarios 10 and 11 are assumed to be laying on the road surface. Values of HOBJ are therefore half the arbitrarily-assigned object vertical dimensions (VO = 1.0 feet) in these scenarios.

Blink Duration

The nominal value for mean blink duration (TAUBM = 0.16 seconds) is taken from Reference 28. No variability is assumed in the duration of blinks (TAUBS = 0).

Response Delay

Model parameters TAURDM and TAURDS are mean and standard deviation of the distribution defining driver response delay following event detection. Nominal values were calculated from data in Reference 29. These data represent drivers' brake reaction time to an auditory stimulus, with a recommended (Reference 29) correction factor applied to account for the increase in response delay of an unalerted driver. Figure G-3 illustrates the approximation of the referenced experimental data by a gamma distribution with TAURDM = 1.0 and TAURDS = 0.37 seconds.

COLLISION-DETERMINATION ALGORITHM PARAMETERS

Vehicle Dimensions

A majority of the parameters in this algorithm provide vehicle dimensional data used to determine occurrence of a collision. Although current nominal data for the SV dynamic model represent a 1971 Dodge Coronet, dimensional data for collision determination are based on vehicle sizes more representative of those anticipated in the 1985 time frame.

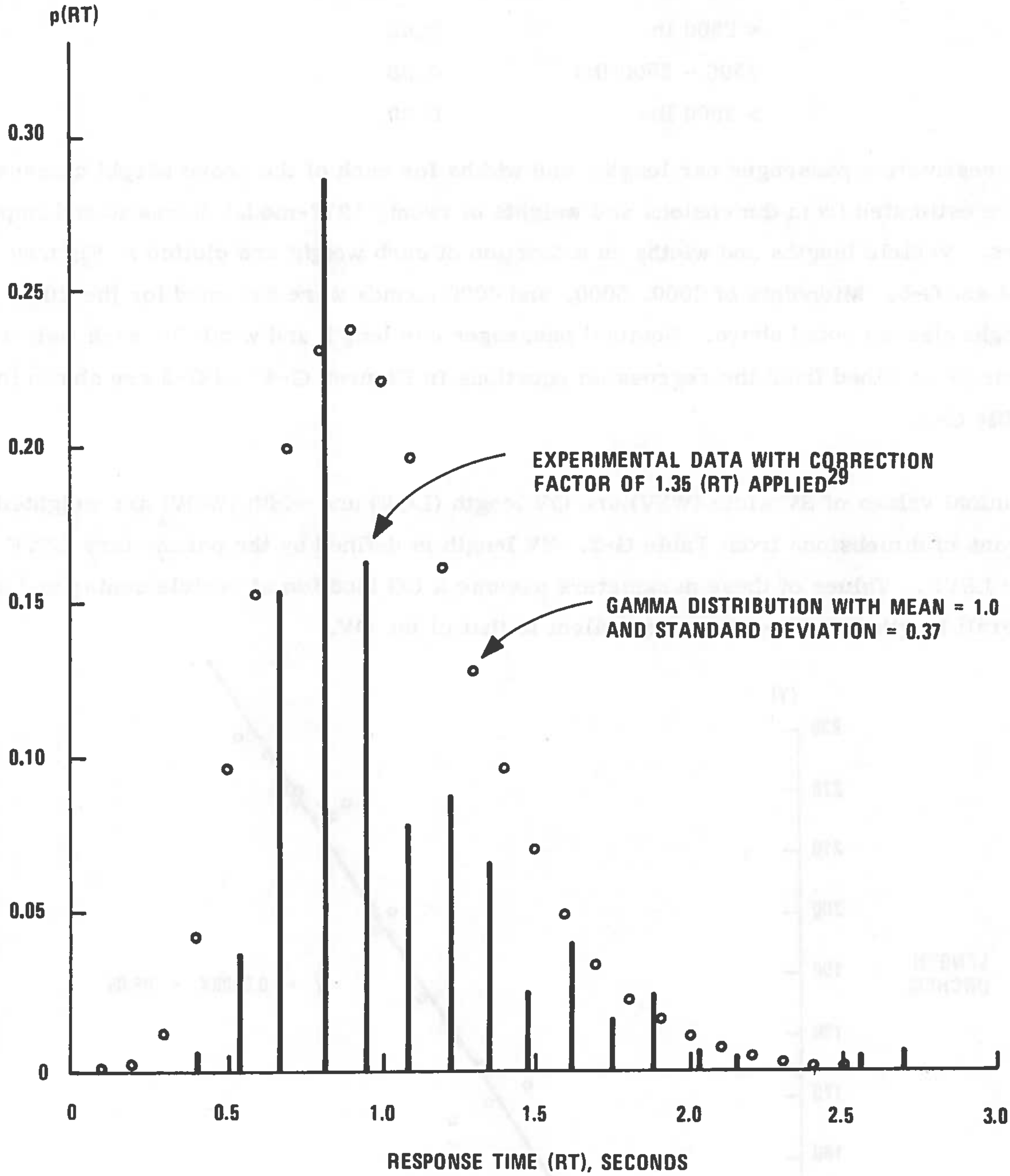

FIGURE G-3. APPROXIMATION OF RESPONSE TIME DATA WITH GAMMA DISTRIBUTION

Published projections of 1985 passenger car mix in terms of proportion of miles driven (Reference 12) can be closely approximated by the following three weight classes.

Weight	Proportion of Miles
< 2500 lbs	0.42
2500 - 3500 lbs	0.38
> 3500 lbs	0.20

Representative passenger car lengths and widths for each of the above wieght classes were estimated from dimensions and weights of twenty 1977-model domestic and import cars. Vehicle lengths and widths as a function of curb weight are plotted in Figures G-4 and G-5. Midpoints of 2000, 3000, and 4000 pounds were assumed for the three weight classes noted above. Nominal passenger car length and width for each weight class determined from the regression equations in Figures G-4 and G-5 are shown in Table G-2.

Nominal values of SV width (WSV) and OV length (LOV) and width (WOV) are weighted means of dimensions from Table G-2. SV length is defined by the parameters LSVF and LSVR. Values of these parameters assume a CG location at vehicle center and an overall length (LSVF + LSVR) equivalent to that of the OV.

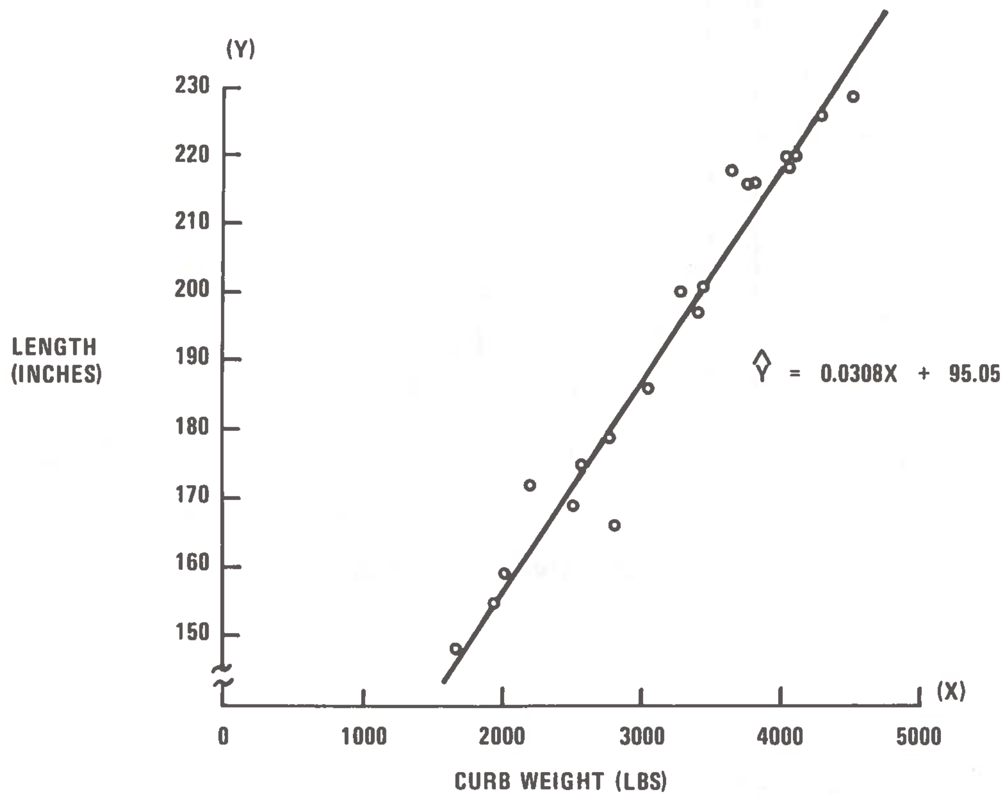

FIGURE G-4. LENGTH AS A FUNCTION OF WEIGHT IN SAMPLE OF 1977-MODEL CARS

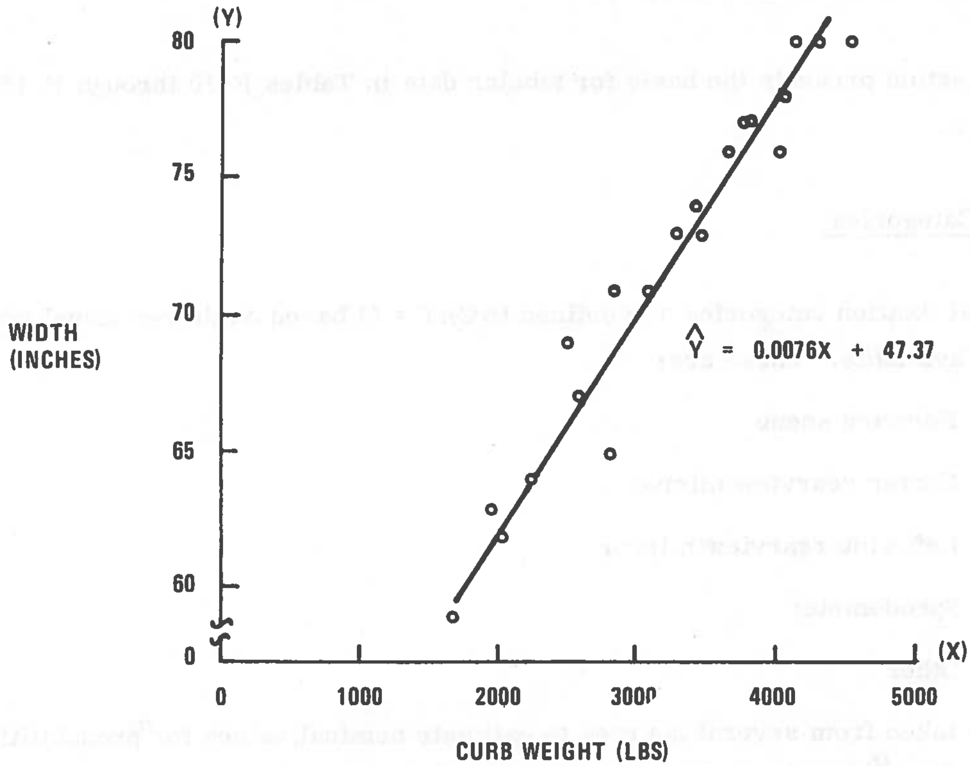

FIGURE G-5. WIDTH AS A FUNCTION OF WEIGHT IN SAMPLE OF 1977 MODEL CARS

TABLE G-2. PASSENGER-CAR MIX CHARACTERISTICS

Weight Class	Proportion of Total Miles Driven	Defining Characteristics of Class		
		Vehicle Weight (lb.)	Vehicle Length (in.)	Vehicle Width (in.)
< 2500 lbs	0.42	2000	157	63
2500 - 3500 lbs	0.38	3000	187	70
> 3500 lbs	0.20	4000	218	78

Velocity Thresholds

Longitudinal and lateral velocity thresholds UHTH and VHTH define SV velocities at which a simulation run is terminated. Nominal values are set to 2.0 feet per second under the assumption that collision velocities below this level are of no practical significance.

DETECTION MODEL TABULAR DATA

This subsection presents the basis for tabular data in Tables F-10 through F-16 of Appendix F.

Fixation Categories

Five visual fixation categories are defined (NCAT = 5) based on driver visual scan data currently available. These are:

1. Forward scene
2. Center rearview mirror
3. Left side rearview mirror
4. Speedometer
5. Other

Data were taken from several sources to estimate nominal values for probabilities of fixation in the i^{th} category, PCAT(I). Data in this form are generally not available, although related data such as proportion of time or mean fixation duration in a category are available for a limited number of driving conditions. Nominal values of PCAT(I) were determined from available data in the following manner.

Let

d_i = mean fixation duration in i^{th} category

n_i = number of fixations in i^{th} category

t_i = time in i^{th} category

T = total time of data collection interval = Σt_i

P_{t_i} = proportion of time in i^{th} category = t_i/T

By definition,

$$PCAT(I) = n_i/\Sigma n_i$$

From the relationships

$$t_i = n_i d_i$$

$$P_{t_i} = t_i/T = n_i d_i/T$$

$$n_i/T = P_{t_i}/d_i$$

$$\Sigma(n_i/T) = \Sigma(P_{t_i}/d_i)$$

$$\frac{n_i/T}{\Sigma(n_i/T)} = \frac{P_{t_i}/d_i}{\Sigma(P_{t_i}/d_i)}$$

fixation probability in the i^{th} category can also be defined by

$$PCAT(I) = \frac{P_{t_i}/d_i}{\Sigma(P_{t_i}/d_i)}$$

The main source of data for determining nominal values of PCAT(I) was a study by Rockwell, et al (Reference 30). Except where otherwise indicated, values of P_{t_i} and d_i in the following Tables G-3 and G-4 are from Tables 4.2 and 4.3 in Reference 30. Data applied in all scenarios except scenario 3 (see Table G-3) were collected while driving in a freeway traffic lane adjacent to an entrance ramp. Data applied in scenario 3 (see Table G-4) were collected while driving on an entrance ramp. Data derived from other sources (References 28, 31, 32) are indicated in these tables.

Although blinks do not represent a fixation category (see previous discussion of parameter TAUBM), blink data are included in Tables G-3 and G-4 since they are involved in calculating nominal values for PCAT(I).

TABLE G-3. BASIS FOR VALUES OF PCAT(I) IN ALL SCENARIOS EXCEPT SCENARIO 3

Category	P_{t_i}	d_i	P_{t_i}/d_i	PCAT(I)
(Blinks)	4.75	0.16*	29.69	0.193
I = 1 (Forward)	79.85	0.76**	105.07	0.683
I = 2 (Center mirror)	5.99	0.733	8.17	0.053
I = 3 (Left mirror)	3.74	1.08	3.45	0.022
I = 4 (Speedometer)	4.60	0.684	6.73	0.044
I = 5 (Other)	1.07	1.44†	0.74	0.005

*From Reference 28, p. 4

**From Reference 31, p. 49

†From Reference 32, Table K-2

TABLE G-4. BASIS FOR VALUES OF PCAT(I) IN SCENARIO 3

Category	P_{t_i}	d_i	P_{t_i}/d_i	PCAT(I)
(Blinks)	6.29	0.16*	39.3	0.251
I = 1 (Forward)	72.6	0.76**	95.49	0.610
I = 2 (Center mirror)	3.43	0.733	4.68	0.030
I = 3 (Left mirror)	15.45	1.08	14.25	0.091
I = 4 (Speedometer)	1.65	0.684	2.41	0.015
I = 5 (Other)	0.61	1.44†	0.42	0.003

*From Reference 28, p. 4

**From Reference 31, p. 49

†From Reference 32, Table K-2

Fixation Distributions

Associated with each of the preceding fixation categories are mean and standard deviatio for fixation elevation angles THFM(I) and THFS(I), azimuth angles PSFM(I) and PSFS(I), and durations TAUFM(I) and TAUFS(I).

No variability is assumed in the direction of glances for fixation categories 2 through 5. Corresponding nominal values are THFS(I) = PSFS(I) = 0 for I = 2 through 5. Values of mean fixation angles THFM(I) and PSFM(I) for I = 2 through 4 (mirrors and speedometer are from Reference 33. The fifth fixation category ("other") is a catch-all category generally not explicitly defined in the literature. In the nominal data, this category is assigned 45-degree fixation angles down and to the right to approximate glances in the general direction of an ashtray, radio, or center console.

Several published studies have yielded data applicable to driver visual scanning of the forward scene (I = 1). A field study by Whalen, et al (Reference 31) was selected as the primary basis for nominal values of THFM(1), THFS(1), PSFM(1), and PSFS(1) under day ambient conditions. Data for scenarios 1, 2, and 6 are from a "freeway traffic driving" condition. For scenarios 3, 4, and 5, Whalen's data for a "car-following with short headway" condition are applied. Scenarios 7, 8, and 9 are assigned data from a condition representing "open road driving at 50 mph" with some traffic present on multilane unidirectional roadway. Scenarios 10 and 11 are characterized by two-lane bidirectional roadway with little or no oncoming traffic. Nominal data for these two scenarios are from a "daytime-straight" condition in Reference 18.

Nominal values of the above four parameters with I = 1 under night ambient conditions were derived entirely from glance distribution data in Reference 18. Considerable subjective judgment was necessary in assigning values because of the limited experimental data available. In scenarios 1, 2, and 6 through 9, it is assumed that a driver would exhibit a fairly dispersed glance distribution across the forward scene due to the relatively large volume of traffic and roadway lighting of other vehicles. On the other hand, it is reasonable to assume that the SV driver would actually have his high beams on in scenario 10 and thus have a more dispersed glance distribution typical of operation with high beams (Reference 18). Therefore, angular distribution characteristics for a straight road condition with existing U.S. high beams (Reference 18) were selected as nominal values in scenarios 1, 2, and 6 through 10. Data from a condition including straight road driving with existing U.S. low beams was selected as a basis for these parameter values in the remaining scenarios 3, 4, 5, and 11.

Nominal values for distribution parameters of fixation duration TAUFM(I) and TAUFS(I) are also estimated from a variety of sources and experimental conditions. Values for fixation categories 2, 3, and 4 for all scenarios except scenario 3 are from the mainstream traffic condition in Reference 30. For scenario 3, values are from the entrance ramp driving condition in this same source.

For fixation category 5 and all scenarios, Reference 32 was employed to provide nominal values. In this case, means and standard deviations of fixation durations prior to planned left and right lane change maneuvers were averaged to provide estimates for the "other" fixation category.

Results from the various driving conditions tested in Reference 31 are the basis of nominal values of TAUFM(I) and TAUFS(I) applicable to the forward scene (I = 1). Data from the "traffic driving condition" are applied in scenarios 1, 2, and 6. Data from the "car following short headway condition" are applied in scenarios 3, 4, and 5. Finally, the condition of "open road driving at 50 mph" is the source of these nominal values in remaining scenarios 7 through 11.

Stationary Glare Sources

Two glare sources (NGLARE = 2) are defined in Appendix F, Tables F-10 and F-11, with nominal values of all associated tabular parameters EG(I), THG(I), and PSG(I) set to zero. Thus, no stationary glare sources are present in the nominal data. Two sources are defined in the data tables simply to illustrate the documentation format.

Line of Sight to Laterally Moving Vehicles

In scenarios 6, 7, and 8, the probability of a clear line of sight to laterally moving vehicles is assumed to be a function of A-pillar and center mirror widths and placement. These vehicle design parameters are definable in the model by assignment of appropriat values to variable PMERG. Nominal data for PMERG were estimated from a represent- ative ambinocular plot of pillar and mirror locations in the driver's field (Reference 32). Although binocular vision of the SV driver is not modeled, effects on line of sight of binocular vision and some degree of eye position variation can be approximated by choic of values in the range $0 < \text{PMERG} < 1$.

Headlamp Luminous Intensities

SV headlamp luminous intensities in the direction of detectable objects (ISVO) and object backgrounds (ISVB) are obtained by interpolation from a one-dimensional data array (see Appendix F, Table F-13). This table contains data only for a vertical/longitudinal plane through the lamp axis since objects to which these data apply (scenarios 9, 10, and 11) are assumed to be directly ahead of the SV. Nominal data are based on maximum and minimum-value isocandela diagrams for a type-3 low beam (Reference 34). Maximum and minimum luminous intensities at each coordinate point were summed to approximate the average luminous intensities of two lamps.

Headlamp luminous intensities from oncoming vehicles (INV) are tabulated in Appendix F, Table F-14. These data apply only to scenarios 4, 5, and 11 and were obtained from the same source as described above (Reference 34). The reason for selecting the particular 6 by 11 degree sector of intensities to characterize INV is discussed in Section 8 (see Figure 8-3).

Contrast Thresholds

Interpolated values from two sets of tabular data (Appendix F, Tables F-15 and F-16) are applied to calculate a threshold object/background contrast for visual conditions present on each fixation. Values of variables CFOVO and CFOVL define threshold contrasts for objects located in foveal vision. Values of variables CPERO and CPERL define a scale factor for incremental contrasts required to account for object eccentricity angle. Generally, threshold contrast would be determined by CPER(CFOV). Since tabular data are transformed by $\log_{10}$, numeric values obtained by interpolation from the two tables are added rather than multiplied (see Equation 8-32 in Section 8).

Foveal threshold contrast data in Table F-15 are based on extrapolations of data reported by Blackwell and Taylor (Reference 35) for a condition involving 0.33-second exposure of a test stimulus directly on the visual axis. These data were then adjusted by adding 0.75 to the resulting $\log_{10}$ contrast values. This adjustment is recommended by Davies (Reference 25) to extrapolate similar laboratory data to more complex real-world visual environments.

The incremental contrast data in Table F-16 to account for off-axis viewing (object eccentricity angle) were obtained by extrapolating data reported by Davies (Reference 25) from work by Taylor (Reference 36). Davies notes that these data are not valid for low-light conditions since foveal visual acuity (relative to peripheral acuity) decreases as ambient luminance decreases. This change becomes most pronounced at luminance levels below approximately 0.04 ft-L (References 27, 37). However, results of a study by Graf and Krebs (Reference 18) indicate that night roadway luminance in the vicinity of the driver's mean fixation point generally varies between 0.3 and 0.8 ft-L for various headlamp beam configurations. A single set of functions as defined in Appendix F, Table F-16 is therefore considered sufficient for the range of ambient luminance and eye adaptation conditions relevant to DRIVEM.

APPENDIX G

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