APPENDIX A

SAS PROGRAMS USED TO ESTIMATE LIVES SAVED BY THE FMVSS AND OTHER VEHICLE SAFETY TECHNOLOGIES, 1960-2002

OVERVIEW

LS2004CR is the program that creates a census file called *LSM2004* of the 1,241,796 fatality cases on the Fatality Analysis Reporting System (FARS) for calendar years 1975 through 2002, on file as of February 27, 2004.[1] It includes all fatalities, non-occupants as well as vehicle occupants, occupants of heavy trucks, unknown vehicles, and other types as well as occupants of cars and LTVs. It includes necessary data elements about the person who was the fatality and the crash. It contains data elements about a vehicle: the vehicle occupied by the fatality, if the fatality was an occupant, or the vehicle that hit the non-occupant. Vehicle data include an analysis of the VIN, based on a series of programs developed and maintained by NHTSA staff since 1991 for use in FMVSS evaluations and other vehicle safety analyses. If the crash is a 2-vehicle crash, data elements are obtained on the "other" vehicle.

LS2004 is the main program that:

- Selects the fatality cases from *LSM2004* that were occupants of cars, occupants of LTVs, non-occupants struck by cars /LTVs, or motorcyclists struck by cars/LTVs.
- Adjusts for missing data on vehicle type or vehicle model year.
- Replaces each case with unknown impact type, seat position or belt/safety seat use by a set of cases, one for each possible value of those variables, weighted by the probability of occurrence of that value – based on analyses of the distribution of these variables, when they are known, as a function of other variables on the file.
- "Removes" the safety technologies from each case vehicle, one-by-one, in the reverse chronological order that they were installed, calculating the increase in the fatality risk, if any, as a consequence.
- Tallies, for the entire file, the number of additional fatalities there would have been if none of the vehicles had been equipped with any safety technologies, and apportions the additional fatalities by safety standard/technology, by vehicle type, by calendar year (1975-2002), and by whether the technology was mandated by a standard already in effect or was voluntarily furnished by the manufacturer at the time the vehicle was built.
- Generates information about CY 1975-80 crashes needed to extend the model to 1960-74, and stores it in three files named *FARS7580*, *PED7580* and *MC7580*.
- Prints out, for each model year, the proportion of cars and LTVs equipped with various safety technologies.

LS2004 includes both the "preprocessor" and the "main model" described in the Summary chapter of Part 2 of this report. Before LS2004 can be successfully operated, it is necessary to

[1] On that day FARS had been complete for the full year 2002 for some time, but selected cases may still be revised in the future.

run nine auxiliary programs that provide the information the preprocessor needs to adjust or distribute the unknowns.

LS_UNK4 finds the proportion of cases in each calendar year where the case vehicle type and/or its model year are unknown, and it develops the factors to adjust the weights of the remaining cases after these cases are deleted from the analysis.

L_CRSH4 creates four files, *CRSH1*, *CRSH2*, *CRSH3* and *CRSH4* that state the probability distribution of fatalities by crash type/impact location as a function of other variables. LS2004 will use these files to impute crash type/impact locations on *LSM2004* cases where they are unknown. For example in single-vehicle crashes, a multinomial logistic regression (CATMOD) calibrates the probability that the crash type/impact location was frontal, side, rollover or rear/other as a function of the specific object struck, the vehicle type, the occupant's age, and the occupant's ejection status, based on cases where everything is known, and it stores these probabilities in *CRSH1*.

L_SEAT4 creates a file, *SEAT1* that states the probability distribution, calibrated by CATMOD, of passenger fatalities by seat position as a function of the passenger's age, the vehicle type and the crash type/impact location. LS2004 will use this file to impute seat positions when they are completely unknown, or when they are just partially known (e.g., front seat, unknown location).

L3PT4 is a binomial logistic regression (LOGIST) of belt use by front-outboard occupants age 6 years or older in vehicles with integral 3-point belts (including automatic 3-point belts) at the front-outboard positions, for fatality cases where the belt use is not reported as "unknown." It calibrates belt use (yes or no) as a function of the calendar year, the occupant's age and gender, the vehicle type, vehicle age, crash type/impact location and seat position (driver or front-right). The regression equation is copied into LS2004, where it will impute the belt use of occupants for whom it is unknown on FARS.

LBK3PT4 similarly calibrates belt use for rear-outboard and rear-center occupants age 6+, in vehicles with integral 3-point belts at the applicable seat position, as a function of the calendar year, the occupant's age and gender, the vehicle type, vehicle age, crash type/impact location and seat position (outboard or center).

L2PT4 calibrates use of automatic 2-point shoulder belts at the front-outboard seats for occupants age 6+, as a function of the type of automatic 2-point belt (motorized or non-motorized), the occupant's age and gender, the vehicle age, crash type/impact location and seat position (driver or front-right). The analysis does not investigate whether the manual lap belt, if one exists, was also used.

L_LAP4 calibrates belt use of occupants age 6+ at seat positions equipped with lap belts only or with separate lap and shoulder belts (front-center in all model years; front-outboard, rear-outboard and rear-center before the shift to integral 3-point belts), as a function of the calendar year, the occupant's age and gender, the vehicle type, vehicle age, crash type/impact location and seat position (driver, front-center, front-right, rear-outboard or rear-center). In the cars with

separate lap and shoulder belts, it merely calibrates if any belt was used, and it does not distinguish between the lap belt, the shoulder belt, or both.

LKIDRES4 comprises two logistic regressions and performs two calibrations of restraint systems use by child passengers age 0-5. The first regression, excluding only the passengers whose restraint use was completely unknown (codes 9 and 99), calibrates the proportion that used any type of restraint (belts, safety seats, or "used, type not specified") versus no restraint at all. The second regression, limited to restrained children where the type of restraint was also known, calibrates the proportion in safety seats versus belts. Both regression equations, as well as those from the three preceding programs, are copied into LS2004.

L_UNR_EJ tabulates the percentages of unrestrained fatalities that were ejected, by vehicle type, age group, seat position and impact location/crash type. These percentages are copied into the belt and safety-seat effectiveness analyses of LS2004.

A preliminary run of LS2004, and another program, NCNA2084, supplies information on the median installation years for the various safety technologies. (NCNA2084 shows the proportion of vehicles on NCSS and NASS files equipped with lap belts or lap/shoulder belts, by seat position, vehicle type and model year.) If any of the safety technologies on the current version of LS2004 are not in the right reverse-chronological order, rearrange the program and run it again. LS2004 generates a complete listing of lives saved by the safety technologies in 1975-2002 and also generates the files named *FARS7580*, *PED7580* and *MC7580* used to describe the distribution of fatalities in 1975-80 and make inferences about the distribution before 1975.

OLDFARS1 and OLDFA14 analyze files named *FARS7580*, *PED7580* and *MC7580* to find the CY 1975-80 distributions of:

- Car occupant fatalities by age of the case vehicle; LTV occupant fatalities by age of the case vehicle; non-occupant fatalities by age of the striking vehicle, when it was a car or LTV; motorcyclist fatalities in collisions with cars or LTVs, by age of the car/LTV.
- Distribution of car and LTV occupant fatalities by impact location/crash type.
- Distribution of car and LTV occupant fatalities by seat position and occupant age group.
- Proportion of fatalities that were ejected, by vehicle type, impact location/crash type, and belt use.
- Belt use by vehicle type, seat position and model year.
- Safety seat use and lap belt use by infants and toddlers.

OLDFA24 is the postprocessor that estimates lives saved in CY 1960-74. It uses information from *Accident Facts* and OLDFA14 to estimate:

- How many fatalities there would have been on FARS in each calendar year, from 1960 to 1974, if FARS had existed.
- How many of them would have been car occupants, LTV occupants, or non-occupants and motorcyclists struck by cars or LTVs.

- The model-year distribution of the cars and LTVs in these crashes, and for the occupant fatalities, their distribution by the vehicle's impact location/crash type, and whether or not the occupant was ejected.
- How many of the occupants were belted, and how many of the vehicles were equipped with the various safety technologies that existed before 1975.

Having created these hypothetical populations of fatal crash cases, OLDFA24 runs through the same model as LS2004, removing the safety technologies from the case vehicles in the reverse chronological order that they were installed, calculating the increase in the fatality risk, if any, as a consequence, and tallying the number of additional fatalities there would have been if none of the vehicles had been equipped with any safety technologies in 1960-74.

Finally, LIFE6002 combines the estimates from LS2004 and OLDFA24 to provide a single printout of the lives saved, year-by-year, in 1960-2002, apportioned by safety standard/ technology, by vehicle type, and by whether the technology was mandated by a standard already in effect or was voluntarily furnished by the manufacturer at the time the vehicle was built. TRND6002 computes occupant fatality rates per 100,000,000 VMT, based on VMT totals derived from *Traffic Safety Facts 2002* and *Accident Facts*.[2]

This overview is followed by complete listings, with commentary, of the long programs LS2004 and OLDFA24. All the other programs are much shorter, generally self-explanatory, or are discussed within the commentary on LS2004 and OLDFA24.

[2] *Traffic Safety Facts 2002*, NHTSA Report No. DOT HS 809 620, Washington, 2004; *Accident Facts*, National Safety Council, Chicago, annual publication.

DESCRIPTION OF THE MAIN ANALYSIS PROGRAM LS2004

Files used to run this program:

```
LIBNAME LIBRARY 'O:\FARSSAS\FORMATS\WINFMT91.610';
LIBNAME LSM2004 'C:\...';
LIBNAME CRSH1 'C:\...';
LIBNAME CRSH2 'C:\...';
LIBNAME CRSH3 'C:\...';
LIBNAME CRSH4 'C:\...';
LIBNAME SEAT1 'C:\...';
```

Files created by this program

```
LIBNAME FARS7580 'C:\...';
LIBNAME PED7580 'C:\...';
LIBNAME MC7580 'C:\...';

OPTION NOCENTER NOFMTERR OBS=5000000 LS=153 PAGESIZE=47;
/*  PROGRAM NAME: LS2004.SAS                    UPDATED: 04/14/2004   */
/*  LIVES SAVED BY FMVSS IN 1975-2002, CARS, LIGHT TRUCKS, PEDS, MCs  */
```

Codes for impact location/crash type (CRSH):

```
PROC FORMAT; VALUE CRSH 1='FRONTAL' 2='SIDE IMPACT'
  3='ROLLOVER (PRIMARY)' 4='REAR & OTHER' 9='UNKNOWN';
```

Codes for vehicle type:

```
PROC FORMAT; VALUE VTYP 1='PASSENGER CAR' 2='LIGHT TRUCK' 3='BIG TRUCK, BUS'
  4='MOTORCYCLE' 5='OTHER' 9='UNKNOWN';

PROC FORMAT; VALUE CYGP 1='1975-81' 2='1982-90' 3='1991-2002';
PROC FORMAT; VALUE MY 1900-1954='PRE-1955' 9999='UNKNOWN';
```

Codes for streamlined seat position variable (SEAT2):

```
PROC FORMAT; VALUE NEWSEAT 11='DRIVER' 12='CENTER FRONT' 13='RIGHT FRONT' 18='OTHER FRONT'
  19='UNK FRONT' 21='OUTBOARD REAR' 22='CENTER REAR' 28='OTHER REAR'
  29='UNK REAR' 51='OTHER ENCLOSED' 52='UNENCLOSED' 99='UNK PASSENGER';

PROC FORMAT; VALUE NEWVTYP 1='CONVERTIBLE' 2='2-DOOR CAR' 4='4-DOOR CAR'
  6='STATION WAGON' 9='CAR, UNK STYLE'
  11='PICKUP TRUCK' 12='S U V' 13='VAN' 19='TRUCK, UNK STYLE';
```

Codes for streamlined restraint use variables (REST2 and REST3):

```
PROC FORMAT; VALUE NEWREST 0='UNRESTRAINED' 1='SHOULDER BELT ONLY' 2='LAP BELT ONLY'
  3='LAP+SHOULDER BELT' 4='CHILD SAFETY SEAT' 7='2-PT AUTOMATIC BELT'
  8='USED, TYPE NOT SPECIFIED' 99='UNKNOWN IF USED';
```

Special codes for analysis of air bags and child passengers:

```
PROC FORMAT; VALUE KCRSH 1='12:00 IMPACT1 OR 2' 2='11,1:00' 3='10,2:00' 4='NONFRONTAL';
PROC FORMAT; VALUE RESTGP 1='INFANT IN CRD' 2='INFANT NOT IN CRD'
  3='AGE 1-5 UNRESTRAINED' 4='AGE 1-5 IN CRD' 5='AGE 1-5 BELTED'
  6='AGE 6-10 UNRESTRAINED' 7='AGE 6-10 BELTED'
  8='AGE 11-12 UNRESTRAINED' 9='AGE 11-12 BELTED';
RUN;
```

The preprocessor section of LS2004 starts here. Selects from *LSM2004*, the census of fatality cases, those fatalities that were occupants of cars or LTVs (OCC1), non-occupants struck by cars or LTVs (PED1) or motorcyclists struck by cars or LTVs (MC1).

```
/* ------------------------------------------------------------------------ */
/* ------------------------------------------------------------------------ */
/*    SUBDIVIDES THE FATALITIES INTO (1) OCCUPANTS OF CARS/LTVs             */
/* (2) NONOCCUPANTS KILLED BY CARS/LTVS (3) MOTORCYCLISTS KILLED BY CAR/LTVs */
/* ADJUSTS ALL NUMBERS UPWARD FOR MISSING DATA ON VEHICLE TYPE OR MODEL YEAR */
/* MY = 0-9 IN CY < 1982 ARE HIGHLY SUSPECT AND WILL BE CONSIDERED MISSING   */
/* ------------------------------------------------------------------------ */
/* ------------------------------------------------------------------------ */

DATA OCC1(KEEP=ORIGWT WEIGHTFA CY MY VTYP IMPACT1 IMPACT2 HARM_EV MAN_COLL
       BOD2 TRKTYP BODY_TYP V1-V8 AGE SEX VE_FORMS CYGP NEWVTYP EJECTION
       SEAT_POS REST_USE AUT_REST PER_TYP LGT_COND CRSH PASSIVE MAK2 MM2 CG
       MAKE MAK_MOD PER_NO OVTYP OIMPACT2 OVCONFIG STATE M_HARM TAPECASE)
     PED1(KEEP=ORIGWT WEIGHTFA CY MY VTYP)
     MC1(KEEP=ORIGWT WEIGHTFA CY OMY OVTYP);
SET LSM2004.LSM2004;
```

Deletes cases with unknown vehicle type, unknown model year, or that did not involve a car/LTV.

```
IF VTYP=. THEN VTYP=9;
IF VTYP IN (1,2) OR (VTYP=4 AND OVTYP IN (1,2));
IF VTYP IN (1,2) AND (MY GT CY+1 OR MY=9999 OR 0 LE MY LE 1909) THEN DELETE;
IF VTYP=4 AND (OMY GT CY+1 OR OMY=9999 OR OMY=. OR 0 LE MY LE 1909) THEN DELETE;

IF VTYP=4 THEN GOTO MCWATE;
IF PER_TYP IN (1,2,9) THEN GOTO OCCWATE;

/* DELETE (AND ADJUST FOR) PARKED-VEHICLE OCC SINCE VTYP/MY ALWAYS UNKNOWN   */
IF (CY LE 1981 AND PER_TYP=5) OR (CY GE 1982 AND PER_TYP=3) THEN DELETE;

/* ------------------------------------------------------------------------ */
/* ADJUSTMENT FACTORS FOR NONOCCUPANTS - OBTAINED BY RUNNING LS_UNK4         */
/* ------------------------------------------------------------------------ */
```

Creates the two weight-factor variables, ORIGWT and WEIGHTFA that will stay with each fatality cases as it proceeds through the model. ORIGWT is the original weight assigned to each fatality case. WEIGHTFA is the inflated weight denoting how many fatalities there would have been if safety technologies were removed from the vehicle. Throughout the preprocessor, WEIGHTFA = ORIGWT.

Having deleted all the cases with unknown vehicle type or model year, must give all the remaining cases an ORIGWT higher than 1, so that the ORIGWTs will add up to the original fatality count, including an allowance for all cases deleted due to missing MY, and an allowance for a portion of the cases with unknown vehicle type – as computed by the program LS_UNK4.

For example, suppose there are 10,000 fatality cases in cars/LTVs with known MY, 100 cases in cars/LTVs with unknown MY, and 200 fatality cases in vehicles of unknown type. Assume also that, when the vehicle type is known, 80 percent are cars/LTVs and 20 percent are heavy trucks, motorcycles or other known types. Then the inflation factor computed by LS_UNK4 would be:

$$[10{,}000 + 100 + (.80 \text{x} 200)] / 10{,}000 = 1.026$$

The vehicle's model year or type is unknown in 9-19 percent of pedestrian crashes, primarily because many of them are hit-and-run.

```
IF CY=1975 THEN WEIGHTFA=1.15080; ELSE IF CY=1976 THEN WEIGHTFA=1.16331;
  ELSE IF CY=1977 THEN WEIGHTFA=1.16595; ELSE IF CY=1978 THEN WEIGHTFA=1.16998;
  ELSE IF CY=1979 THEN WEIGHTFA=1.17921; ELSE IF CY=1980 THEN WEIGHTFA=1.18698;
  ELSE IF CY=1981 THEN WEIGHTFA=1.20951; ELSE IF CY=1982 THEN WEIGHTFA=1.13142;
  ELSE IF CY=1983 THEN WEIGHTFA=1.11566; ELSE IF CY=1984 THEN WEIGHTFA=1.11156;
  ELSE IF CY=1985 THEN WEIGHTFA=1.12026; ELSE IF CY=1986 THEN WEIGHTFA=1.11781;
  ELSE IF CY=1987 THEN WEIGHTFA=1.11672; ELSE IF CY=1988 THEN WEIGHTFA=1.11157;
  ELSE IF CY=1989 THEN WEIGHTFA=1.12342; ELSE IF CY=1990 THEN WEIGHTFA=1.11187;
  ELSE IF CY=1991 THEN WEIGHTFA=1.11680; ELSE IF CY=1992 THEN WEIGHTFA=1.10650;
  ELSE IF CY=1993 THEN WEIGHTFA=1.10809; ELSE IF CY=1994 THEN WEIGHTFA=1.10696;
  ELSE IF CY=1995 THEN WEIGHTFA=1.10145; ELSE IF CY=1996 THEN WEIGHTFA=1.10478;
  ELSE IF CY=1997 THEN WEIGHTFA=1.10029; ELSE IF CY=1998 THEN WEIGHTFA=1.09377;
  ELSE IF CY=1999 THEN WEIGHTFA=1.09198; ELSE IF CY=2000 THEN WEIGHTFA=1.09535;
  ELSE IF CY=2001 THEN WEIGHTFA=1.10633; ELSE IF CY=2002 THEN WEIGHTFA=1.11733;
  ORIGWT=WEIGHTFA;
  OUTPUT PED1; RETURN;

/* ------------------------------------------------------------------------ */
/* ADJUSTMENT FACTORS FOR MOTORCYCLISTS - OBTAINED BY RUNNING LS_UNK4       */
/* ------------------------------------------------------------------------ */

MCWATE: IF CY=1975 THEN WEIGHTFA=1.03029; ELSE IF CY=1976 THEN WEIGHTFA=1.03235;
  ELSE IF CY=1977 THEN WEIGHTFA=1.02838; ELSE IF CY=1978 THEN WEIGHTFA=1.01218;
  ELSE IF CY=1979 THEN WEIGHTFA=1.00780; ELSE IF CY=1980 THEN WEIGHTFA=1.00795;
  ELSE IF CY=1981 THEN WEIGHTFA=1.01466; ELSE IF CY=1982 THEN WEIGHTFA=1.01772;
  ELSE IF CY=1983 THEN WEIGHTFA=1.01923; ELSE IF CY=1984 THEN WEIGHTFA=1.02307;
  ELSE IF CY=1985 THEN WEIGHTFA=1.02295; ELSE IF CY=1986 THEN WEIGHTFA=1.01927;
  ELSE IF CY=1987 THEN WEIGHTFA=1.02442; ELSE IF CY=1988 THEN WEIGHTFA=1.01736;
  ELSE IF CY=1989 THEN WEIGHTFA=1.01430; ELSE IF CY=1990 THEN WEIGHTFA=1.02179;
  ELSE IF CY=1991 THEN WEIGHTFA=1.02575; ELSE IF CY=1992 THEN WEIGHTFA=1.00806;
  ELSE IF CY=1993 THEN WEIGHTFA=1.01340; ELSE IF CY=1994 THEN WEIGHTFA=1.01456;
  ELSE IF CY=1995 THEN WEIGHTFA=1.01144; ELSE IF CY=1996 THEN WEIGHTFA=1.01047;
  ELSE IF CY=1997 THEN WEIGHTFA=1.01546; ELSE IF CY=1998 THEN WEIGHTFA=1.01122;
  ELSE IF CY=1999 THEN WEIGHTFA=1.01471; ELSE IF CY=2000 THEN WEIGHTFA=1.01027;
  ELSE IF CY=2001 THEN WEIGHTFA=1.01655; ELSE IF CY=2002 THEN WEIGHTFA=1.01231;
  ORIGWT=WEIGHTFA;
  OUTPUT MC1; RETURN;

/* ------------------------------------------------------------------------ */
/* ADJUSTMENT FACTORS FOR CAR/LTV OCCUPANTS - OBTAINED BY RUNNING LS_UNK4   */
/* INCLUDES OCCUPANTS OF PARKED VEHICLES                                    */
/* ------------------------------------------------------------------------ */
```

In recent years, the vehicle type and model year have been known in well over 99 percent of the occupant fatality cases on FARS.

```
OCCWATE: IF CY=1975 THEN WEIGHTFA=1.02596; ELSE IF CY=1976 THEN WEIGHTFA=1.02452;
  ELSE IF CY=1977 THEN WEIGHTFA=1.02496; ELSE IF CY=1978 THEN WEIGHTFA=1.01685;
  ELSE IF CY=1979 THEN WEIGHTFA=1.01236; ELSE IF CY=1980 THEN WEIGHTFA=1.01104;
  ELSE IF CY=1981 THEN WEIGHTFA=1.01537; ELSE IF CY=1982 THEN WEIGHTFA=1.01228;
  ELSE IF CY=1983 THEN WEIGHTFA=1.00685; ELSE IF CY=1984 THEN WEIGHTFA=1.00814;
  ELSE IF CY=1985 THEN WEIGHTFA=1.01133; ELSE IF CY=1986 THEN WEIGHTFA=1.00817;
  ELSE IF CY=1987 THEN WEIGHTFA=1.00883; ELSE IF CY=1988 THEN WEIGHTFA=1.00627;
  ELSE IF CY=1989 THEN WEIGHTFA=1.00802; ELSE IF CY=1990 THEN WEIGHTFA=1.00643;
  ELSE IF CY=1991 THEN WEIGHTFA=1.00580; ELSE IF CY=1992 THEN WEIGHTFA=1.00448;
  ELSE IF CY=1993 THEN WEIGHTFA=1.00658; ELSE IF CY=1994 THEN WEIGHTFA=1.00539;
  ELSE IF CY=1995 THEN WEIGHTFA=1.00559; ELSE IF CY=1996 THEN WEIGHTFA=1.00640;
  ELSE IF CY=1997 THEN WEIGHTFA=1.00659; ELSE IF CY=1998 THEN WEIGHTFA=1.00474;
  ELSE IF CY=1999 THEN WEIGHTFA=1.00456; ELSE IF CY=2000 THEN WEIGHTFA=1.00404;
  ELSE IF CY=2001 THEN WEIGHTFA=1.00437; ELSE IF CY=2002 THEN WEIGHTFA=1.00905;
  ORIGWT=WEIGHTFA;
```

```
/* DEFINES THE CRASH CONFIGURATION                                          */
```

The CRSH variable (1 = frontal, 2 = side, 3 = rollover, 4 = rear/other) is critically important because the effectiveness of many of the safety technologies varies by crash type. First-harmful-event fires, immersions and other non-collision types are included in the rear/other category. If the principal impact (IMPACT2) is unknown, rely on the initial impact (IMPACT1).

```
IF IMPACT2=13 OR HARM_EV=1     THEN CRSH=3;
  ELSE IF 2 LE HARM_EV LE 6    THEN CRSH=4;
  ELSE IF 5 LE IMPACT2 LE 7    THEN CRSH=4;
  ELSE IF 8 LE IMPACT2 LE 10   THEN CRSH=2;
  ELSE IF 2 LE IMPACT2 LE 4    THEN CRSH=2;
  ELSE IF IMPACT2 IN (1,11,12) THEN CRSH=1;
  ELSE IF HARM_EV=7            THEN CRSH=4;
  ELSE IF IMPACT1=13           THEN CRSH=3;
  ELSE IF 5 LE IMPACT1 LE 7    THEN CRSH=4;
  ELSE IF 8 LE IMPACT1 LE 10   THEN CRSH=2;
  ELSE IF 2 LE IMPACT1 LE 4    THEN CRSH=2;
  ELSE IF IMPACT1 IN (1,11,12) THEN CRSH=1;

/*  (HEAD-ON COLLISION INVOLVMENTS ARE ASSUMED TO BE FRONTAL IMPACTS) */
  ELSE IF MAN_COLL=2           THEN CRSH=1;

  ELSE                              CRSH=9;

/* DEFINES THE CALENDAR YEAR GROUPS (MAJOR CHANGES IN FARS DATA DEFINITIONS) */
IF 1975 LE CY LE 1981 THEN CYGP=1;
  ELSE IF 1982 LE CY LE 1990 THEN CYGP=2;
  ELSE IF CY GE 1991 THEN CYGP=3;

/* DEFINES THE VEHICLE BODY TYPE (N OF CAR DOORS, PICKUP, SUV, VAN)   */
IF VTYP=1 THEN DO;
IF BOD2 IN (1,2,4,6,9) THEN NEWVTYP=BOD2;
  ELSE IF BOD2 IN (3,7) THEN NEWVTYP=2;
  ELSE IF BOD2 IN (5,8) THEN NEWVTYP=4;
  ELSE IF CYGP=1 THEN DO;
    IF BODY_TYP IN (1,2,6,9) THEN NEWVTYP=BODY_TYP;
    ELSE IF BODY_TYP=3 THEN NEWVTYP=4; ELSE NEWVTYP=9; END;
  ELSE IF CYGP IN (2,3) THEN DO;
    IF BODY_TYP IN (1,2,4,6,9) THEN NEWVTYP=BODY_TYP;
    ELSE IF BODY_TYP=3 THEN NEWVTYP=2;
    ELSE IF BODY_TYP=5 THEN NEWVTYP=4; ELSE NEWVTYP=9; END; END;

ELSE IF VTYP=2 THEN DO;
IF TRKTYP IN (1,2) THEN NEWVTYP=11;
  ELSE IF TRKTYP IN (3,4) THEN NEWVTYP=12;
  ELSE IF TRKTYP IN (5,6) THEN NEWVTYP=13;
  ELSE IF TRKTYP IN (7,8,9) THEN NEWVTYP=19;
  ELSE IF CYGP=1 THEN DO;
    IF BODY_TYP=50 THEN NEWVTYP=11;
    ELSE IF BODY_TYP IN (43,52) THEN NEWVTYP=12;
    ELSE IF BODY_TYP=51 THEN NEWVTYP=13; ELSE NEWVTYP=19; END;
  ELSE IF CYGP=2 THEN DO;
    IF BODY_TYP IN (50,51) THEN NEWVTYP=11;
    ELSE IF BODY_TYP IN (12,55,56) THEN NEWVTYP=12;
    ELSE IF BODY_TYP=40 THEN NEWVTYP=13; ELSE NEWVTYP=19; END;
  ELSE IF CYGP=3 THEN DO;
    IF BODY_TYP IN (30,31,32,39) THEN NEWVTYP=11;
    ELSE IF BODY_TYP IN (14,15,16,19) THEN NEWVTYP=12;
    ELSE IF BODY_TYP IN (20,21) THEN NEWVTYP=13; ELSE NEWVTYP=19; END; END;

OUTPUT OCC1;
RUN;
```

Next is the main analysis section for non-occupant fatalities: pedestrians, bicyclists and other non-motorists that were struck by cars or LTVs. Two safety technologies, dual master cylinders (105A) and front disc brakes (105B) saved non-occupant lives because they enabled car/LTV drivers to avoid hitting the non-occupants. The model is simpler here because it involves just those two technologies, but the setup is basically the same as for car and LTV occupant fatalities.

```
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
/*  ANALYZES EFFECT OF BRAKE IMPROVEMENTS ON NONOCCUPANT FATALITIES   */
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */

DATA PED2; SET PED1;
/* IMPLEMENTATION OF FRONT DISC BRAKES IN THE VEHICLES THAT HIT THESE PEDESTRIANS */
```

Proceed in reverse chronological order: disc brakes first because they were installed later. Ideally, we should determine if the vehicle (that hit the pedestrian) was equipped with front disc brakes. However, we don't know whether specific vehicles were equipped or not equipped. We only know, based on the vehicle's model year, what percent of vehicles were equipped in that model year. PS105B + PV105B is the percentage of vehicles, in any given model year, that had front disc brakes; PS105B are the installations after FMVSS 105 was amended, effective 1/1/1976 in cars and 9/1/1983 in LTVs, to include performance tests most easily met with disc brakes; PV105B are any disc-brake installations before the standard was amended. PS = "proportion, standard" PV = "proportion voluntary"

```
  IF MY GE 1984 THEN DO; PS105B=1; PV105B=0; END;
    ELSE IF MY LE 1964 THEN DO; PS105B=0; PV105B=0; END;
    ELSE IF MY=1965 THEN DO; PS105B=0; PV105B=.02; END;
    ELSE IF MY=1966 THEN DO; PS105B=0; PV105B=.03; END;
    ELSE IF MY=1967 THEN DO; PS105B=0; PV105B=.06; END;
    ELSE IF MY=1968 THEN DO; PS105B=0; PV105B=.13; END;
    ELSE IF MY=1969 THEN DO; PS105B=0; PV105B=.28; END;
    ELSE IF MY=1970 THEN DO; PS105B=0; PV105B=.41; END;
    ELSE IF MY=1971 THEN DO; PS105B=0; PV105B=.63; END;
    ELSE IF MY=1972 THEN DO; PS105B=0; PV105B=.74; END;
    ELSE IF MY=1973 THEN DO; PS105B=0; PV105B=.86; END;
    ELSE IF MY=1974 THEN DO; PS105B=0; PV105B=.84; END;
    ELSE IF MY=1975 THEN DO; PS105B=0; PV105B=.93; END;
    ELSE IF MY=1976 AND CY=1975 THEN DO; PS105B=0; PV105B=.99; END;
    ELSE IF MY=1976 AND VTYP=1 THEN DO; PS105B=.50; PV105B=.49; END;
    ELSE IF MY=1976 AND VTYP=2 THEN DO; PS105B=0; PV105B=.99; END;
    ELSE IF 1977 LE MY LE 1983 AND VTYP=1 THEN DO; PS105B=1; PV105B=0; END;
    ELSE IF 1977 LE MY LE 1983 AND VTYP=2 THEN DO; PS105B=0; PV105B=1; END;
```

Thus, for example, in MY 1971, PV105B = .63 because 63 percent of cars (and we assume also LTVs) were equipped with front disc brakes, voluntarily, before the amendment to FMVSS 105. Note that PV105B > 0 even in MY 1976, because nearly half of MY 1976 cars were produced before 1/1/1976.

```
/* IMPLEMENTATION OF DUAL MASTER CYLINDERS IN THE VEHICLES THAT HIT THESE PEDESTRIANS */
  IF MY GE 1984 THEN DO; PS105A=1; PV105A=0; END;
    ELSE IF MY LE 1961 THEN DO; PS105A=0; PV105A=0; END;
    ELSE IF MY IN (1962,1963) THEN DO; PS105A=0; PV105A=.09; END;
    ELSE IF MY IN (1964,1965) THEN DO; PS105A=0; PV105A=.07; END;
    ELSE IF MY=1966 THEN DO; PS105A=0; PV105A=.54; END;
    ELSE IF MY=1967 THEN DO; PS105A=0; PV105A=1; END;
    ELSE IF MY=1968 AND VTYP=1 THEN DO; PS105A=.5; PV105A=.5; END;
    ELSE IF MY=1968 AND VTYP=2 THEN DO; PS105A=0; PV105A=1; END;
```

```
    ELSE IF 1969 LE MY LE 1983 AND VTYP=1 THEN DO; PS105A=1; PV105A=0; END;
    ELSE IF 1969 LE MY LE 1983 AND VTYP=2 THEN DO; PS105A=0; PV105A=1; END;
```

Here is the basic routine for estimating lives saved by a safety technology, specifically non-occupant lives saved by front disc brakes. All effectiveness estimates are derived from NHTSA evaluation reports and discussed in Part 1 of this report. NHTSA's evaluation estimated that front disc brakes reduced fatal crash involvements by 0.17 percent. Effectiveness, E = .0017. P = PS105B + PV105B is the probability that the case vehicle was equipped with front disc brakes (based on its model year). Up to this point in the model, this case has a weight of WEIGHTFA fatalities, renamed OLDWTFA. There would have been OLDWTFA / (1 – E x P) fatalities if the vehicle had no front disc brakes at all rather than a P probability of disc brakes. That becomes the new value of WEIGHTFA. S = OLDWTFA x E x P / (1 – E x P) is the difference between the new WEIGHTFA and the OLDWTFA, and it is the increase in fatalities that would have occurred in the complete absence of front disc brakes. S is apportioned between lives saved by post-standard installations of disc brakes (PLS105B) and voluntary installations of disc brakes (PLV105B). The new value of WEIGHTFA here will become the old value (OLDWTFA) in the next step (dual master cylinders).

PLV105B: "P" = pedestrian, "L" = lives saved, "V" = voluntary, "105B" = front disc brakes

```
/* PEDESTRIAN LIVES SAVED BY FRONT DISC BRAKES */
  OLDWTFA=WEIGHTFA;
  IF PS105B GT 0 OR PV105B GT 0 THEN DO;
    E=.0017;
    P=PS105B+PV105B;
    S=OLDWTFA*E*P / (1 - E*P);
    PLS105B=S*PS105B/P;
    PLV105B=S*PV105B/P;
    WEIGHTFA=OLDWTFA+PLS105B+PLV105B; END;
  ELSE DO; PLS105B=0; PLV105B=0; END;
```

NHTSA's evaluation estimated that dual master cylinders reduced fatal crash involvements by 0.7 percent.

```
/* PEDESTRIAN LIVES SAVED BY DUAL MASTER CYLINDERS */
  OLDWTFA=WEIGHTFA;
  IF PS105A GT 0 OR PV105A GT 0 THEN DO;
    E=.007;
    P=PS105A+PV105A;
    S=OLDWTFA*E*P / (1 - E*P);
    PLS105A=S*PS105A/P;
    PLV105A=S*PV105A/P;
    WEIGHTFA=OLDWTFA+PLS105A+PLV105A; END;
  ELSE DO; PLS105A=0; PLV105A=0; END;
  PLS=PLS105A+PLS105B; PLV=PLV105A+PLV105B;
  PL105A=PLS105A+PLV105A; PL105B=PLS105B+PLV105B; PL=PLS+PLV;
```

At this point, the model has "removed" all applicable safety technologies from the vehicles, and WEIGHTFA indicates the implicit number of non-occupant fatalities in the absence of front disc brakes and dual master cylinders on the case car/LTV.

```
RUN;
```

Adds up the actual fatality cases (ORIGWT), the estimate of how many fatalities there would have been if all safety technologies had been removed from the vehicles (WEIGHTFA), and the lives saved by each technology, by calendar year. PLV = total non-occupant lives saved (voluntary

installations). PLS = total non-occupant lives saved (post-standard installations). PL = PLV + PLS = total non-occupant lives saved by all technologies.

```
PROC MEANS SUM NOPRINT DATA=PED2; BY CY;
  VAR ORIGWT WEIGHTFA PLV105B PLS105B PL105B PLV105A PLS105A PL105A PLV PLS PL;
  OUTPUT OUT=PED3
    SUM=P_ORIGWT P_WTFA PLV105B PLS105B PL105B PLV105A PLS105A PL105A PLV PLS PL;
```

Prints out the totals for each calendar year, and the sum for all years, 1975-2002.

```
PROC PRINT DATA=PED3;
  FORMAT P_ORIGWT P_WTFA PLV105B PLS105B PL105B PLV105A PLS105A PL105A PLV PLS PL 9.0;
  ID CY; VAR P_ORIGWT P_WTFA PLV105B PLS105B PL105B PLV105A PLS105A PL105A PLV PLS PL;
  SUM P_ORIGWT P_WTFA PLV105B PLS105B PL105B PLV105A PLS105A PL105A PLV PLS PL;
TITLE1 'PEDESTRIANS SAVED BY CAR/LIGHT TRUCK DISC BRAKES AND DUAL MASTER CYLINDERS, 1975-2002';
TITLE2 ' ';
TITLE3 '...105B = FRONT DISC BRAKES (MEDIAN INSTALLATION YEAR 1971, FMVSS EFFECTIVE 1/1/76 OR
9/1/83)';
TITLE4 '...105A = DUAL MASTER CYLINDERS (MEDIAN INSTALLATION YEAR LATE 1966, FMVSS EFFECTIVE 1/1/68
OR 9/1/83)';
TITLE5 '...V = VOLUNTARY INSTALLATIONS, BEFORE EFFECTIVE DATE';
TITLE6 '...S = STANDARD INSTALLATIONS, AFTER EFFECTIVE DATE';
TITLE7 'P_ORIGWT = ACTUAL PED/BIKE/NONMOTORIST FATALITIES';
TITLE8 'P_WTFA = FATALITIES THAT WOULD HAVE OCCURRED WITHOUT THESE SAFETY IMPROVEMENTS';
TITLE9 'PL = OVERALL PED/BIKE/NONMOTORIST LIVES SAVED BY BRAKE IMPROVEMENTS IN CARS/LIGHT TRUCKS';
RUN;

/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
/*  ANALYZES EFFECT OF BRAKE IMPROVEMENTS ON MOTORCYCLIST FATALITIES  */
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
```

Next is the main analysis for motorcyclist fatalities in collisions with cars/LTVs. The model is exactly the same as for non-occupants, except lives-saved estimates are named “MLV105B” instead of “PLV105B,” etc. (“M” = motorcyclist) OMY = the model year of the car/LTV that hit the motorcycle.

```
DATA MC2; SET MC1;
/* IMPLEMENTATION OF FRONT DISC BRAKES IN THE VEHICLES THAT HIT THESE MOTORCYCLES */
  IF OMY GE 1984 THEN DO; MS105B=1; MV105B=0; END;
    ELSE IF OMY LE 1964 THEN DO; MS105B=0; MV105B=0; END;
    ELSE IF OMY=1965 THEN DO; MS105B=0; MV105B=.02; END;
    ELSE IF OMY=1966 THEN DO; MS105B=0; MV105B=.03; END;
    ELSE IF OMY=1967 THEN DO; MS105B=0; MV105B=.06; END;
    ELSE IF OMY=1968 THEN DO; MS105B=0; MV105B=.13; END;
    ELSE IF OMY=1969 THEN DO; MS105B=0; MV105B=.28; END;
    ELSE IF OMY=1970 THEN DO; MS105B=0; MV105B=.41; END;
    ELSE IF OMY=1971 THEN DO; MS105B=0; MV105B=.63; END;
    ELSE IF OMY=1972 THEN DO; MS105B=0; MV105B=.74; END;
    ELSE IF OMY=1973 THEN DO; MS105B=0; MV105B=.86; END;
    ELSE IF OMY=1974 THEN DO; MS105B=0; MV105B=.84; END;
    ELSE IF OMY=1975 THEN DO; MS105B=0; MV105B=.93; END;
    ELSE IF OMY=1976 AND CY=1975 THEN DO; MS105B=0; MV105B=.99; END;
    ELSE IF OMY=1976 AND OVTYP=1 THEN DO; MS105B=.50; MV105B=.49; END;
    ELSE IF OMY=1976 AND OVTYP=2 THEN DO; MS105B=0; MV105B=.99; END;
    ELSE IF 1977 LE OMY LE 1983 AND OVTYP=1 THEN DO; MS105B=1; MV105B=0; END;
    ELSE IF 1977 LE OMY LE 1983 AND OVTYP=2 THEN DO; MS105B=0; MV105B=1; END;
/* IMMLEMENTATION OF DUAL MASTER CYLINDERS IN THE VEHICLES THAT HIT THESE MOTORCYCLES */
  IF OMY GE 1984 THEN DO; MS105A=1; MV105A=0; END;
    ELSE IF OMY LE 1961 THEN DO; MS105A=0; MV105A=0; END;
    ELSE IF OMY IN (1962,1963) THEN DO; MS105A=0; MV105A=.09; END;
```

```
    ELSE IF OMY IN (1964,1965) THEN DO; MS105A=0; MV105A=.07; END;
    ELSE IF OMY=1966 THEN DO; MS105A=0; MV105A=.54; END;
    ELSE IF OMY=1967 THEN DO; MS105A=0; MV105A=1; END;
    ELSE IF OMY=1968 AND OVTYP=1 THEN DO; MS105A=.5; MV105A=.5; END;
    ELSE IF OMY=1968 AND OVTYP=2 THEN DO; MS105A=0; MV105A=1; END;
    ELSE IF 1969 LE OMY LE 1983 AND OVTYP=1 THEN DO; MS105A=1; MV105A=0; END;
    ELSE IF 1969 LE OMY LE 1983 AND OVTYP=2 THEN DO; MS105A=0; MV105A=1; END;
/* MOTORCYLIST LIVES SAVED BY FRONT DISC BRAKES */
  OLDWTFA=WEIGHTFA;
  IF MS105B GT 0 OR MV105B GT 0 THEN DO;
    E=.0017;
    P=MS105B+MV105B;
    S=OLDWTFA*E*P / (1 - E*P);
    MLS105B=S*MS105B/P;
    MLV105B=S*MV105B/P;
    WEIGHTFA=OLDWTFA+MLS105B+MLV105B; END;
  ELSE DO; MLS105B=0; MLV105B=0; END;
/* MOTORCYCLIST LIVES SAVED BY DUAL MASTER CYLINDERS */
  OLDWTFA=WEIGHTFA;
  IF MS105A GT 0 OR MV105A GT 0 THEN DO;
    E=.007;
    P=MS105A+MV105A;
    S=OLDWTFA*E*P / (1 - E*P);
    MLS105A=S*MS105A/P;
    MLV105A=S*MV105A/P;
    WEIGHTFA=OLDWTFA+MLS105A+MLV105A; END;
  ELSE DO; MLS105A=0; MLV105A=0; END;
  MLS=MLS105A+MLS105B; MLV=MLV105A+MLV105B;
  ML105A=MLS105A+MLV105A; ML105B=MLS105B+MLV105B; ML=MLS+MLV;
RUN;

PROC MEANS SUM NOPRINT DATA=MC2; BY CY;
  VAR ORIGWT WEIGHTFA MLV105B MLS105B ML105B MLV105A MLS105A ML105A MLV MLS ML;
  OUTPUT OUT=MC3
    SUM=M_ORIGWT M_WTFA MLV105B MLS105B ML105B MLV105A MLS105A ML105A MLV MLS ML;
PROC PRINT DATA=MC3;
  FORMAT M_ORIGWT M_WTFA MLV105B MLS105B ML105B MLV105A MLS105A ML105A MLV MLS ML 9.0;
  ID CY; VAR M_ORIGWT M_WTFA MLV105B MLS105B ML105B MLV105A MLS105A ML105A MLV MLS ML;
  SUM M_ORIGWT M_WTFA MLV105B MLS105B ML105B MLV105A MLS105A ML105A MLV MLS ML;
TITLE1 'MOTORCYCLISTS SAVED BY CAR/LIGHT TRUCK DISC BRAKES AND DUAL MASTER CYLINDERS, 1975-2002';
TITLE2 ' ';
TITLE3 '...105B = FRONT DISC BRAKES (MEDIAN INSTALLATION YEAR 1971, FMVSS EFFECTIVE 1/1/76 OR
9/1/83)';
TITLE4 '...105A = DUAL MASTER CYLINDERS (MEDIAN INSTALLATION YEAR LATE 1966, FMVSS EFFECTIVE 1/1/68
OR 9/1/83)';
TITLE5 '...V = VOLUNTARY INSTALLATIONS, BEFORE EFFECTIVE DATE';
TITLE6 '...S = STANDARD INSTALLATIONS, AFTER EFFECTIVE DATE';
TITLE7 'M_ORIGWT = ACTUAL MOTORCYLIST FATALITIES IN COLLISIONS WITH A CAR OR LTV';
TITLE8 'M_WTFA = FATALITIES THAT WOULD HAVE OCCURRED WITHOUT THESE SAFETY IMPROVEMENTS';
TITLE9 'ML = OVERALL MOTORCYCLIST LIVES SAVED BY BRAKE IMPROVEMENTS IN CARS/LIGHT TRUCKS';
RUN;
```

The program now turns to car/LTV occupant fatalities, and it returns to the pre-processor section, splitting cases with unknown crash mode, seat position or restraint use into two or more cases with known, imputed values for these variables.

```
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
/*  THE ANALYSIS OF OCCUPANT FATALITIES BEGINS HERE                   */
/*  FIRST TASK IS TO IMPUTE ALL UNKOWN CRASHMODES, SEAT POS, BELT USE */
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */

proc freq data=occ1; weight origwt; format crsh crsh.; tables crsh;
```

```
TITLE 'UNKNOWN CRSH IN OCC1';
run;
```

Splits the file OCC1 into OCC2 and UNKCRSH1. OCC2 are the cases with known impact location/crash type (CRSH) and are left alone. UNKCRSH1 contains the cases with unknown crash mode (CRSH = 9).

```
DATA OCC2 UNKCRSH1; SET OCC1;
IF CRSH=9 THEN OUTPUT UNKCRSH1; ELSE OUTPUT OCC2;
RUN;
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
/*  DISTRIBUTES AND IMPUTES CRASH MODES WHEN THEY ARE UNKNOWN         */
/*  SEPARATE IMPUTATIONS FOR FIXED OBJECT, ANGLE, REAR-END AND        */
/*  OTHER CRASHES BASED ON CATMOD MODELS DEVELOPED IN L_CRSH4.SAS     */
/*  (HEAD-ON COLLISION INVOLVMENTS ARE ASSUMED TO BE FRONTAL IMPACTS) */
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
```

UNKCRSH1, in turn, is split into FIXOBJ, ANGLE, REAR, OTH; the first consists of single-vehicle crashes with unknown crash mode; the second, multivehicle crashes described as “angle collisions” (MAN_COLL = 1,3); the third, rear-end collisions; the fourth, all other crash involvements. Defines various subgroups of first harmful event and seat position/age/gender. These groupings, together with vehicle type and occupant ejection, are good predictors of whether the impact was frontal, side, rollover, or rear/other.

```
DATA FIXOBJ ANGLE REAR OTH;
SET UNKCRSH1;
IF HARM_EV IN (10,11,12,14,18,24,30,34,35,42,43,99) THEN EVENT1=HARM_EV;
  ELSE IF HARM_EV IN (8,9,15,44,47) THEN EVENT1=99;
  ELSE IF HARM_EV=13 THEN EVENT1=12;
  ELSE IF HARM_EV IN (16,19,22,48) THEN EVENT1=34;
  ELSE IF HARM_EV=17 THEN EVENT1=18;
  ELSE IF HARM_EV IN (20,23,26) THEN EVENT1=24;
  ELSE IF HARM_EV IN (21,25,32,36,37,38,39,46) THEN EVENT1=35;
  ELSE IF HARM_EV IN (27,29,40) THEN EVENT1=42;
  ELSE IF HARM_EV=28 THEN EVENT1=30;
  ELSE IF HARM_EV IN (31,33,41) THEN EVENT1=43;
  ELSE IF HARM_EV=45 THEN EVENT1=14;
  ELSE IF HARM_EV=49 THEN EVENT1=11;
  ELSE EVENT1=99;
IF EVENT1=12 THEN DO;
    IF MAN_COLL IN (1,3) THEN EVENT2=12.1;
    ELSE IF MAN_COLL=4 THEN EVENT2=12.2;
    ELSE IF MAN_COLL IN (5,6,7) THEN EVENT2=12.3;
    ELSE EVENT2=99; END;
  ELSE EVENT2=EVENT1;
IF EJECTION IN (1,2) THEN EJECT=1; ELSE EJECT=0;
IF PER_TYP=2 THEN DO; AGEGP3=1;
    IF 0 LE AGE LE 15 THEN AGEGP4=1; ELSE AGEGP4=2; END;
  ELSE DO; IF 14 LE AGE LE 29 THEN AGEGP3=2;
      ELSE IF 30 LE AGE LE 49 THEN AGEGP3=3;
      ELSE IF 50 LE AGE LE 97 THEN AGEGP3=4;
      ELSE AGEGP3=2;
    IF SEX=1 THEN AGEGP4=3; ELSE IF SEX=2 THEN AGEGP4=4; END;
IF 14 LE EVENT2 LE 43 THEN OUTPUT FIXOBJ;
  ELSE IF EVENT2 IN (10,12.2) THEN OUTPUT ANGLE;
  ELSE IF EVENT2=12.1 THEN OUTPUT REAR;
  ELSE OUTPUT OTH;
RUN;

/* ------------------------------------------------------------------ */
```

```
/*  CRSH1.CRSH1 ASSIGNS FIXED-OBJECT CRASHES TO FRONTAL, SIDE, ROLLOVER   */
/*  OR REAR BASED ON FIRST HARMFUL EVENT, EJECTION, DRV/PAS AGE, CAR/LTRK */
/* ---------------------------------------------------------------------- */
```

CRSH1 was generated by the program L_CRSH4 by a CATMOD analysis of the cases with known crash modes. For each combination of EVENT2, EJECT, AGEGP3 and VTYP, CATMOD calibrates the proportions of fatalities that are frontal, side, rollover and rear/other, and it stores these proportions in *CRSH1*. For example, a typical record on *CRSH1* could look like:

Event2	Eject	Agegp3	Vtyp	Frontal	Side	Roll	Rearothr
42 (tree)	0	2 (young drv)	1 (car)	.58	.35	.05	.02

In other words, when a young car driver initially hits a tree, and is fatally injured but not ejected, 58 percent of the crashes with known crash type are frontals, 35 percent are side impacts, 5 percent are classified as rollovers for the purpose of this model because the principal impact location is the top of the car (due to a subsequent rollover), and 2 percent are rear/other.

```
PROC SORT DATA=FIXOBJ; BY EVENT2 EJECT AGEGP3 VTYP;
```

The information from *CRSH1* is added to each case.

```
DATA FIXOBJ2; MERGE FIXOBJ(IN=OCC) CRSH1.CRSH1;
  BY EVENT2 EJECT AGEGP3 VTYP; IF OCC;
```

Now each original case with unknown crash mode is split into four separate cases with known crash modes. For example, if the original case had a weight factor (ORIGWT = WEIGHTFA) of 1, and it was a young non-ejected car driver who hit a tree, create four cases, with the same values as the original case on all variables except CRSH, ORIGWT and WEIGHTFA. The first case will have CRSH = 1 (frontal) and ORIGWT = WEIGHTFA = .58. The second case will have CRSH = 2 (side) and ORIGWT = WEIGHTFA = .35. The third case will have CRSH = 3 (rollover) and ORIGWT = WEIGHTFA = .05. The fourth case will have CRSH = 4 (rear/other) and ORIGWT = WEIGHTFA = .02. The four cases, together will have ORIGWTs adding up to 1, like the initial case.

```
DATA FIXOBJ3; SET FIXOBJ2;
O1=ORIGWT; W1=WEIGHTFA;
CRSH=1; ORIGWT=FRONTAL * O1; WEIGHTFA=FRONTAL * W1; OUTPUT;
CRSH=2; ORIGWT=SIDE    * O1; WEIGHTFA=SIDE    * W1; OUTPUT;
CRSH=3; ORIGWT=ROLL    * O1; WEIGHTFA=ROLL    * W1; OUTPUT;
CRSH=4; ORIGWT=REAROTHR* O1; WEIGHTFA=REAROTHR* W1; OUTPUT;

/* ---------------------------------------------------------------------- */
/*  CRSH2.CRSH2 ASSIGNS MULTIVEH ANGLE COLLISIONS TO FRONTAL, SIDE, ROLL  */
/*  OR REAR BASED ON FIRST HARMFUL EVENT, EJECTION, DRV/PAS AGE, CAR/LTRK */
/* ---------------------------------------------------------------------- */

PROC SORT DATA=ANGLE; BY EVENT2 EJECT AGEGP4 VTYP;
DATA ANGLE2; MERGE ANGLE(IN=OCC) CRSH2.CRSH2;
  BY EVENT2 EJECT AGEGP4 VTYP; IF OCC;
DATA ANGLE3; SET ANGLE2;
O1=ORIGWT; W1=WEIGHTFA;
CRSH=1; ORIGWT=FRONTAL * O1; WEIGHTFA=FRONTAL * W1; OUTPUT;
CRSH=2; ORIGWT=SIDE    * O1; WEIGHTFA=SIDE    * W1; OUTPUT;
CRSH=3; ORIGWT=ROLL    * O1; WEIGHTFA=ROLL    * W1; OUTPUT;
CRSH=4; ORIGWT=REAROTHR* O1; WEIGHTFA=REAROTHR* W1; OUTPUT;
```

```
/* ------------------------------------------------------------------- */
/*  CRSH3.CRSH3 ASSIGNS MULTIVEH REAR-END COLLSNS TO FRONTAL, SIDE, ROLL  */
/*  OR REAR BASED ON EJECTION, DRV/PAS AGE, CAR/LTRK                    */
/* ------------------------------------------------------------------- */

PROC SORT DATA=REAR; BY EVENT2 EJECT AGEGP4 VTYP;
DATA REAR2; MERGE REAR(IN=OCC) CRSH3.CRSH3;
  BY EVENT2 EJECT AGEGP4 VTYP; IF OCC;
DATA REAR3; SET REAR2;
O1=ORIGWT; W1=WEIGHTFA;
CRSH=1; ORIGWT=FRONTAL * O1; WEIGHTFA=FRONTAL * W1; OUTPUT;
CRSH=2; ORIGWT=SIDE    * O1; WEIGHTFA=SIDE    * W1; OUTPUT;
CRSH=3; ORIGWT=ROLL    * O1; WEIGHTFA=ROLL    * W1; OUTPUT;
CRSH=4; ORIGWT=REAROTHR* O1; WEIGHTFA=REAROTHR* W1; OUTPUT;

/* ------------------------------------------------------------------- */
/*  CRSH4.CRSH4 ASSIGNS OTHER-EVENT CRASHES TO FRONTAL, SIDE, ROLLOVER    */
/*  OR REAR BASED ON FIRST HARMFUL EVENT, EJECTION                      */
/* ------------------------------------------------------------------- */

PROC SORT DATA=OTH; BY EVENT2 EJECT;
DATA OTH2; MERGE OTH(IN=OCC) CRSH4.CRSH4;
  BY EVENT2 EJECT; IF OCC;
DATA OTH3; SET OTH2;
O1=ORIGWT; W1=WEIGHTFA;
CRSH=1; ORIGWT=FRONTAL * O1; WEIGHTFA=FRONTAL * W1; OUTPUT;
CRSH=2; ORIGWT=SIDE    * O1; WEIGHTFA=SIDE    * W1; OUTPUT;
CRSH=3; ORIGWT=ROLL    * O1; WEIGHTFA=ROLL    * W1; OUTPUT;
CRSH=4; ORIGWT=REAROTHR* O1; WEIGHTFA=REAROTHR* W1; OUTPUT;
```

UNKCRSH2 contains all the newly created cases with known crash modes. It is appended to OCC2, the original cases with known crash modes, creating OCC3, a file on which all cases have known crash modes.

```
DATA UNKCRSH2; SET FIXOBJ3 ANGLE3 REAR3 OTH3;
DROP EVENT1 EVENT2 AGEGP3 AGEGP4 FRONTAL SIDE ROLL REAROTHR EJECT O1 W1 N;
RUN;

DATA OCC3; SET OCC2 UNKCRSH2;
```

The next step is to replace unknown seat positions with known seat positions. All drivers (PER_TYP = 1) are assumed to be in the left-front seat. Passengers (PER_TYP = 2) might have an unknown seat position. A special case is vehicles where multiple people were ejected and killed, and it is unknown who was the driver (PER_TYP = 9).

```
/* WHEN THERE ARE MULTIPLE (EJECTED) OCCUPANTS, UNKNOWN WHO WAS THE DRIVER,   */
/* ARBITRARILY SAY PER_NO 1 IS THE DRIVER, SINCE IT HARDLY AFFECTS OUR MODEL  */
IF PER_TYP=9 THEN DO;
  IF 0 LE AGE LE 14 THEN PER_TYP=2;
    ELSE IF SEAT_POS NE 1 AND SEAT_POS NE 11 AND SEAT_POS NE 19 AND
      SEAT_POS NE 99 THEN PER_TYP=2;
    ELSE IF PER_NO=1 THEN PER_TYP=1;
    ELSE PER_TYP=2; END;
```

Before the imputation of seat positions, some simplifications of the SEAT_POS variable on FARS are needed. (For example, before 1982, FARS coded seat positions 1, 2, 3, 4, 5, 6 rather than 11, 12, 13, 21, 22, 23.)

```
/* ------------------------------------------------------------------------ */
/* STREAMLINES SEAT_POS CATEGORIES AND MAKES UNIFORM ACROSS 3 GENERATIONS OF FARS */
/* IN VANS, ETC., 3rd AND 4th ROW OF SEATS ARE TREATED AS REAR SEATS          */
```

```
/* ------------------------------------------------------------------------- */

IF PER_TYP=1 AND 0 LE AGE LE 9 THEN DO; PER_TYP=2; SEAT_POS=17; END;
  ELSE IF PER_TYP=1 THEN SEAT_POS=11;
  ELSE IF PER_TYP=2 AND
    ((CYGP IN (2,3) AND SEAT_POS=11) OR (CYGP=1 AND SEAT_POS=1)) THEN SEAT_POS=17;
  ELSE IF PER_TYP=2 AND CYGP=1 THEN DO;
    IF 2 LE SEAT_POS LE 3 THEN SEAT_POS=SEAT_POS+10;
    ELSE IF 4 LE SEAT_POS LE 6 THEN SEAT_POS=SEAT_POS+17;
    ELSE IF 7 LE SEAT_POS LE 9 THEN SEAT_POS=SEAT_POS+24;
    ELSE IF SEAT_POS=10 THEN SEAT_POS=18;
    ELSE IF SEAT_POS=11 THEN SEAT_POS=28;
    ELSE IF SEAT_POS=12 THEN SEAT_POS=38;
    ELSE IF SEAT_POS=13 THEN SEAT_POS=51;
    ELSE IF SEAT_POS=14 THEN SEAT_POS=50;
    ELSE IF SEAT_POS=15 THEN SEAT_POS=55; END;

IF VTYP=1 THEN DO; IF SEAT_POS IN (11,12,13,18,19,51,99) THEN SEAT2=SEAT_POS;
  ELSE IF SEAT_POS=17 THEN SEAT2=18;
  ELSE IF SEAT_POS IN (21,23) THEN SEAT2=21;
  ELSE IF SEAT_POS IN (22,31,32,33) THEN SEAT2=22;
  ELSE IF SEAT_POS IN (28,38,41,42,43,48,49) THEN SEAT2=28;
  ELSE IF SEAT_POS IN (29,39) THEN SEAT2=29;
  ELSE IF SEAT_POS IN (50,52,53,54,55) THEN SEAT2=52; END;
ELSE DO; IF SEAT_POS IN (11,12,13,18,19,51,99) THEN SEAT2=SEAT_POS;
  ELSE IF SEAT_POS=17 THEN SEAT2=18;
  ELSE IF SEAT_POS IN (21,23,31,33,41,43) THEN SEAT2=21;
  ELSE IF SEAT_POS IN (22,32,42) THEN SEAT2=22;
  ELSE IF SEAT_POS IN (28,38,48) THEN SEAT2=28;
  ELSE IF SEAT_POS IN (29,39,49) THEN SEAT2=29;
  ELSE IF SEAT_POS IN (50,52,53,54,55) THEN SEAT2=52; END;
RUN;
```

The SEAT2 codes are: 11=driver 12=center front 13=right front 18=other front 19=unknown front 21=outboard rear 22=center rear 28=other rear 29=unknown rear 51=other enclosed 52=unenclosed 99=unknown passenger. Note: a child sitting on the driver's lap is coded 18, "other front."

```
proc freq data=occ3; weight origwt; format seat2 newseat.; tables seat2;
TITLE 'UNKNOWN SEAT2 IN OCC3';
run;
```

The imputation of seat position is quite similar to the procedure for imputing crash modes. The file OCC3 is split into OCC4 and UNKSEAT1. OCC4 are the cases with known seat position (SEAT2) and are left alone. UNKSEAT1 contains the cases with unknown seat position (SEAT2 = 19, 29, 99).

```
DATA OCC4 UNKSEAT1; SET OCC3;
IF SEAT2 IN (19,29,99) THEN OUTPUT UNKSEAT1; ELSE OUTPUT OCC4;
RUN;

/* ------------------------------------------------------------------ */
/*  DISTRIBUTES AND IMPUTES PASSENGER SEAT POSITIONS WHEN UNKNOWN.    */
/*  SEPARATE IMPUTATIONS FOR TOTALLY UNKNOWN, FRONT-UNKNOWN AND       */
/*  REAR-UNKNOWN PASSENGERS, BASED ON CATMOD MODEL IN LSEAT4.SAS      */
/* ------------------------------------------------------------------ */
```

UNKSEAT1 is further split into the cases where the seat position is entirely unknown (SEAT2 = 99) and the cases where it is known that the occupant was in the front seat, or in a back seat, but the exact location is unknown.

```
DATA USEAT119 USEAT129 USEAT199; SET UNKSEAT1;
```

```
IF AGE=0 THEN AGEGP2=1;
  ELSE IF  1 LE AGE LE  4 THEN AGEGP2=2;
  ELSE IF  5 LE AGE LE 10 THEN AGEGP2=3;
  ELSE IF 11 LE AGE LE 15 THEN AGEGP2=4;
  ELSE IF 16 LE AGE LE 19 THEN AGEGP2=5;
  ELSE IF 20 LE AGE LE 29 THEN AGEGP2=6;
  ELSE IF 30 LE AGE LE 97 THEN AGEGP2=7; ELSE AGEGP2=6;
IF SEAT2=19 THEN OUTPUT USEAT119;
  ELSE IF SEAT2=29 THEN OUTPUT USEAT129;
  ELSE IF SEAT2=99 THEN OUTPUT USEAT199;
RUN;
```

The program L_SEAT4 uses CATMOD to calibrate the distribution of passengers' known seat positions by detailed vehicle type (NEWVTYP), passengers' age group (AGEGP2), and CRSH. On a file *SEAT1*, it stores the proportions of passengers who are in the center-front seat, the right-front seat, and at any of the other known seat positions included in SEAT2, and it stores them in the data elements SEAT12, SEAT13, etc. These are the proportions that will be imputed if the seat position is completely unknown.

However, if we know the passenger was in the front seat, but we don't know exactly where, we can impute them by the proportions SEAT12 / (SEAT12 + SEAT13 + SEAT18), etc.

```
DATA PSEAT19; SET SEAT1.SEAT1;
P1=SEAT12+SEAT13+SEAT18;
SEAT12=SEAT12/P1; SEAT13=SEAT13/P1; SEAT18=SEAT18/P1;
KEEP NEWVTYP AGEGP2 CRSH SEAT12 SEAT13 SEAT18;

DATA PSEAT29; SET SEAT1.SEAT1;
P2=SEAT21+SEAT22+SEAT28;
SEAT21=SEAT21/P2; SEAT22=SEAT22/P2; SEAT28=SEAT28/P2;
KEEP NEWVTYP AGEGP2 CRSH SEAT21 SEAT22 SEAT28;
RUN;
```

Just as in the imputation of crash modes, split each case with unknown seat position into multiple cases with known seat position, each weighted by the probability that the passenger was in that position.

```
PROC SORT DATA=USEAT119; BY NEWVTYP AGEGP2 CRSH;
DATA USEAT219; MERGE USEAT119(IN=OCC) PSEAT19;
  BY NEWVTYP AGEGP2 CRSH; IF OCC;
DATA USEAT319; SET USEAT219;
O1=ORIGWT; W1=WEIGHTFA;
SEAT2=12; ORIGWT=SEAT12 * O1; WEIGHTFA=SEAT12 * W1; OUTPUT;
SEAT2=13; ORIGWT=SEAT13 * O1; WEIGHTFA=SEAT13 * W1; OUTPUT;
SEAT2=18; ORIGWT=SEAT18 * O1; WEIGHTFA=SEAT18 * W1; OUTPUT;

PROC SORT DATA=USEAT129; BY NEWVTYP AGEGP2 CRSH;
DATA USEAT229; MERGE USEAT129(IN=OCC) PSEAT29;
  BY NEWVTYP AGEGP2 CRSH; IF OCC;
DATA USEAT329; SET USEAT229;
O1=ORIGWT; W1=WEIGHTFA;
SEAT2=21; ORIGWT=SEAT21 * O1; WEIGHTFA=SEAT21 * W1; OUTPUT;
SEAT2=22; ORIGWT=SEAT22 * O1; WEIGHTFA=SEAT22 * W1; OUTPUT;
SEAT2=28; ORIGWT=SEAT28 * O1; WEIGHTFA=SEAT28 * W1; OUTPUT;

PROC SORT DATA=USEAT199; BY NEWVTYP AGEGP2 CRSH;
DATA USEAT299; MERGE USEAT199(IN=OCC) SEAT1.SEAT1;
  BY NEWVTYP AGEGP2 CRSH; IF OCC;
DATA USEAT399; SET USEAT299;
O1=ORIGWT; W1=WEIGHTFA;
```

```
SEAT2=12; ORIGWT=SEAT12 * O1; WEIGHTFA=SEAT12 * W1; OUTPUT;
SEAT2=13; ORIGWT=SEAT13 * O1; WEIGHTFA=SEAT13 * W1; OUTPUT;
SEAT2=18; ORIGWT=SEAT18 * O1; WEIGHTFA=SEAT18 * W1; OUTPUT;
SEAT2=21; ORIGWT=SEAT21 * O1; WEIGHTFA=SEAT21 * W1; OUTPUT;
SEAT2=22; ORIGWT=SEAT22 * O1; WEIGHTFA=SEAT22 * W1; OUTPUT;
SEAT2=28; ORIGWT=SEAT28 * O1; WEIGHTFA=SEAT28 * W1; OUTPUT;
SEAT2=51; ORIGWT=SEAT51 * O1; WEIGHTFA=SEAT51 * W1; OUTPUT;
SEAT2=52; ORIGWT=SEAT52 * O1; WEIGHTFA=SEAT52 * W1; OUTPUT;
```

UNKSEAT2 contains all the newly created cases with known seat positions. It is appended to OCC4, the original cases with known seat positions, creating OCC5, a file on which all cases have known seat positions (and crash modes).

```
DATA UNKSEAT2; SET USEAT319 USEAT329 USEAT399;
DROP AGEGP2 SEAT12 SEAT13 SEAT18 SEAT21 SEAT22 SEAT28 SEAT51 SEAT52 O1 W1;
RUN;
```

The next step is to replace unknown belt (or safety seat) use with known restraint use. Before the imputation of restraint use, it is necessary to determine exactly what sort(s) of belt systems were installed at each seat. For front-outboard seats of cars starting in MY 1981 and LTVs in 1985, a detailed VIN analysis has already been performed on the FARS cases, and the information is stored in the variable PASSIVE that is already on the file *LSM2004* and carried over to OCC5. For the other vehicles/seat positions, restraint availability is determined from the VIN-based make-model codes MAK2, CG and MM2, or from the FARS codes MAKE and MAK_MOD. The information is encoded in the variables FTLS (for the front-outboard seats), BKLS (for the rear-outboard seats), and CBKLS (for the rear-center seats). In vans, the "rear" seats include the 3rd and 4th rows as well as the 2nd. The "lap belts only" code really means "lap belts only, if anything." Front-center seats and third seats in station wagons are assumed to have lap belts only.

```
/* ------------------------------------------------------------------ */
/*  FTLS: 3=FRONT OUTBOARD SEATS HAVE 3-POINT BELTS                   */
/*        2=AUTOMATIC 2-POINT BELTS                                   */
/*        1=LAP BELTS ONLY                                            */
/*        4=3-POINT BELTS FOR DRIVER, AUTOMATIC 2-POINT BELTS FOR RF  */
/*        5=SEPARATE MANUAL LAP AND TORSO BELTS                       */
/*        6=MIX OF 3-POINT BELTS AND LAP-ONLY BELTS                   */
/*        7=MIX OF SEPARATE LAP AND TORSO BELTS AND LAP-ONLY BELTS    */
/*        8=MIX OF 3-POINT BELTS AND 2-POINT AUTOMATIC BELTS          */
/*                                                                    */
/*  BKLS: 3=OUTBOARD BACK SEATS HAVE 3-POINT BELTS                    */
/*        1=LAP BELTS ONLY                                            */
/*                                                                    */
/* CBKLS: 3=CENTER BACK SEATS HAVE 3-POINT BELTS                      */
/*        1=LAP BELTS ONLY                                            */
/*                                                                    */
/*  CENTER FRONT SEATS AND STATION-WAGON 3RD SEATS: LAP BELT ONLY     */
/*  OTHER (NONSTANDARD) SEATS HAVE NO BELTS AT ALL                    */
/*  KIDS UNDER 6 CAN ONLY USE SAFETY SEATS OR LAP BELTS               */
/*  PEOPLE AGE 10 OR OLDER ARE NEVER IN CHILD SAFETY SEATS            */
/* ------------------------------------------------------------------ */

DATA OCC5; SET OCC4 UNKSEAT2;
```

The program now edits the original restraint use code on FARS, REST_USE in three steps, generating REST1, then REST2, then REST3, comprising the following codes: 0=unrestrained 1=shoulder belt only 2=lap belt only 3=lap + shoulder belt 4=child safety seat 7=2-pt automatic belt 8=used, type not specified 99=unknown if used.

REST1 is a slight streamlining of REST_USE, changing codes used in earlier versions of FARS to current codes. Children age 0-5 will be considered protected by "lap belts only" when FARS says they wore lap and shoulder belts.

```
IF REST_USE=13 AND PER_TYP=2 AND 0 LE AGE LE 5 THEN REST1=2;
  ELSE IF REST_USE=13 THEN REST1=8;
  ELSE IF REST_USE=14 THEN REST1=4;
  ELSE IF REST_USE=9 THEN REST1=99; ELSE REST1=REST_USE;
IF (1977 LE CY LE 1979 AND AUT_REST=5) OR
  (1980 LE CY LE 1989 AND AUT_REST=1) THEN REST1=7;
```

REST2 edits REST1, taking into account what types of belts were actually in the vehicle and modifying implausible codes. Anybody age 10 or older will be considered to have unknown restraint use if FARS says they were in a child safety seat. "Motorcycle helmet" will always be recoded "unknown" for car/LTV occupants. People in non-designated seat positions (e.g., unenclosed areas) are assumed to be unrestrained.

```
IF SEAT2 IN (17,18,28,51,52) THEN REST2=0;
  ELSE IF REST1=5 THEN REST2=99;
  ELSE IF REST1=4 AND AGE GE 10 THEN REST2=99;
  ELSE REST2=REST1;
```

Belt type installed in front-outboard seats, passenger cars. In 1969-73, VW, Audi, BMW, Mercedes and Volvo are assumed to have 3-point belts, while other makes had separate lap and shoulder belts.

```
IF VTYP=1 THEN DO;
  IF PASSIVE IN (303,404,606,707,1303,1404,1606,1313) THEN FTLS=2;
    ELSE IF PASSIVE IN (1003,1004,1006) THEN FTLS=4;
    ELSE IF MAK_MOD IN (3006,3036,30036) AND 1975 LE MY LE 1980 THEN FTLS=8;
    ELSE IF 1974 LE MY LE 2002 THEN FTLS=3;
    ELSE IF 1969 LE MY LE 1973 AND MAKE IN (30,32,34,42,51) THEN FTLS=3;
    ELSE IF 1965 LE MY LE 1968 AND MAKE=51 THEN FTLS=3;
    ELSE IF 1969 LE MY LE 1973 THEN FTLS=5;
    ELSE IF MY=1968 AND MAKE IN (30,32,34,42) THEN FTLS=6;
    ELSE IF MY=1968 THEN FTLS=7;
    ELSE FTLS=1; END;
```

Belt type installed in front-outboard seats, LTVs. All LTVs had 3-point belts from MY 1981 onwards. All pickup trucks from 1977 onwards. All LTVs had only lap belts (if anything) up to 1968; SUVs and vans up to 1973. In 1969-80, LTVs could have lap belts, or 3-point belts, or a mix of the two, depending on the make, MY and vehicle type. In the absence of specific evidence, a mix of the two is assumed.

```
ELSE IF VTYP=2 THEN DO;
  IF 1981 LE MY LE 2002 THEN FTLS=3;
    ELSE IF MY LE 1968 THEN FTLS=1;
    ELSE IF MAKE=30 THEN FTLS=3;
    ELSE IF NEWVTYP=11 THEN DO;
      IF 1977 LE MY LE 1980 THEN FTLS=3;
        ELSE IF 2 LE MAKE LE 29 AND 1974 LE MY LE 1976 THEN FTLS=6;
        ELSE IF 2 LE MAKE LE 29 THEN FTLS=1;
        ELSE IF 31 LE MAKE LE 84 AND 1975 LE MY LE 1976 THEN FTLS=3;
        ELSE IF 31 LE MAKE LE 84 AND 1972 LE MY LE 1974 THEN FTLS=6;
        ELSE IF 31 LE MAKE LE 84 THEN FTLS=1;
        ELSE IF 1972 LE MY LE 1976 THEN FTLS=6; ELSE FTLS=1; END;
    ELSE IF NEWVTYP=12 THEN DO;
      IF 1969 LE MY LE 1973 THEN FTLS=1;
        ELSE IF MAKE IN (1,2,3,29,84) THEN FTLS=6;
```

```
        ELSE IF MAKE IN (7,9,20,23) AND 1974 LE MY LE 1976 THEN FTLS=6;
        ELSE IF MAKE IN (7,9,20,23) THEN FTLS=3;
        ELSE IF MAKE=12 AND 1974 LE MY LE 1977 THEN FTLS=6;
        ELSE IF MAKE=12 THEN FTLS=3;
        ELSE IF MAKE=49 AND 1974 LE MY LE 1975 THEN FTLS=1;
        ELSE IF MAKE=49 THEN FTLS=3; ELSE FTLS=6; END;
    ELSE IF 1969 LE MY LE 1973 THEN FTLS=1;
    ELSE IF 1974 LE MY LE 1979 THEN FTLS=6;
    ELSE IF MY=1980 THEN FTLS=3; END;
```

TY = first model year with 3-point belts at the back outboard seats. These dates are documented in NHTSA's evaluation of back seat belts.

```
IF MAK2=51 OR (MAK2=. AND MAKE=51) THEN TY=1971;
    ELSE IF VTYP=1 AND (MAK2=42 OR (MAK2=. AND MAKE=42)) THEN TY=1974;
    ELSE IF MM2=39032 THEN TY=1977;
    ELSE IF VTYP=1 AND
     (MAK2 IN (34,44,45,47) OR MAK2=. AND MAKE IN (34,44,45,47)) THEN TY=1981;
    ELSE IF MM2 IN (37032,32035) THEN TY=1982;
    ELSE IF MM2=30041 OR MAK2=32 OR (MAK2=. AND MAKE=32) THEN TY=1983;
    ELSE IF MAK2=56 OR (MAK2=. AND MAKE=56) THEN TY=1986;
    ELSE IF MM2=30040 THEN TY=1985;
    ELSE IF MM2=54032 THEN TY=1986;
    ELSE IF MM2 IN (35039,54032,61031,39031) THEN TY=1987;
    ELSE IF MM2 IN (6018,7018,12017,14017,13005,18005,19005,19014,21005,20019,
      30042,30044,54031,37031,37033,41035,41037,41043,41044,46044,49040,49035,
      60031,22031) OR (MM2=19003 AND CG=18042) OR
      (CG=18052 AND MM2 IN (18002,21002,22002)) THEN TY=1988;
    ELSE IF MM2 IN (7017,9017,7019,9019,12004,14004,18016,20016,22016,20009,22009,
      18017,20017,21017,22017,18003,19003,21003,18018,21018,22018,18020,20020,21020,
      22020,35042,35032,41034,49032,49034,49033,49038,7034,9034,52035,6035,52031,
      7044,9044,52034,10034,20034,53034,55033) OR CG IN (18039,18040,18048)
      THEN TY=1989;
  ELSE IF VTYP=1 THEN TY=1990;
    ELSE IF CG=38301 AND V7='8' THEN TY=1987;
    ELSE IF CG IN (18402,18403,38301,38303,38304) THEN TY=1988;
    ELSE IF CG IN (18301,18303,18304,18401,41401,49301,49302,49401,52301,53302,53303)
      THEN TY=1989;
    ELSE IF CG IN (18302,18404,18405,35301) THEN TY=1990;
    ELSE IF CG IN (1303,1304,1305,6301,6402,6403,6405,6406,18305,49303,49402)
      THEN TY=1991;
  ELSE IF VTYP=2 THEN TY=1992;
IF MY GE TY THEN BKLS=3; ELSE BKLS=1;
```

CTY = first model year with 3-point belts at the center-rear seat. This is documented in NHTSA brochures from MY 1999 onwards. There is limited information on earlier vehicles in NHTSA crash files. All cars and LTVs will be required to have 3-point belts by MY 2008.

```
IF MAK2 IN (47,51) THEN CTY=1994;
  ELSE IF (VTYP=1 AND MAK2 IN (13,58)) OR
     MM2 IN (19014,19017,20032,30046,32042,34035,35039,37032,37402,39032,
             41035,41037,42048,49032,49040,49043,52040,54035,54036,55033,
             59031,59032,59034,62307) OR CG IN (12039,49303) THEN CTY=1999;
  ELSE IF MM2 IN (12037,18002,19003,20002,30040,30042,32044,35043,35047,
                  39034,42303,42307,48034,49045,52034,64032) THEN CTY=2000;
  ELSE IF MAK2 IN (42,48) OR (VTYP=1 AND MAK2 IN (6,7,9)) OR
     MM2 IN (6302,21022,22002,22352,22353,24005,24006,32047,49046,49322,
             49323,49342,49343,49352,49353,54323,59035,59332,59333) THEN CTY=2001;
  ELSE IF MAK2=62 OR MM2 IN (7214,7215,20036,32043,32046,34037,34303,37031,52046,
                  52336,52337,55035,55038,63034) OR

/* ------------------------------------------------------------------------ */
/* ADD SATURN VUE TO THE 2002 LIST AFTER YOU DEFINE ITS CG AND MM2          */
```

```
/* ADD MERCURY MARAUDER ETC. TO THE 2003 LIST AFTER YOU DEFINE ITS CG AND MM2  */
/* ------------------------------------------------------------------------- */

     CG IN (6305,18314,18315,18316,37303) THEN CTY=2002;
  ELSE IF MAK2 IN (13,19,24,32) OR (VTYP=1 AND MAK2 IN (41,49)) OR
     MM2 IN (12016,12017,12300,12301,12302,12303,12306,12307,12308,
             12312,12313,13312,13313,14016,14017,14302,14303,14308,
             20016,22016,22032,37322,49302,49303,52333,53033,55036) OR
     CG IN (18210,18311,18312) THEN CTY=2003;
  ELSE CTY=2008;                              /* FINAL DATE IN ANTON'S LAW */
IF MY GE CTY THEN CBKLS=3; ELSE CBKLS=1;

DROP TY CTY;
RUN;

proc freq data=occ5; weight origwt; format rest2 newrest.; tables rest2;
TITLE 'UNKNOWN REST2 IN OCC5';
run;
```

OCC5 is split into OCC6 and UNKBELT1. OCC6 are the cases with known restraint use (REST2) and are left alone. UNKBELT1 contains the cases with unknown restraint use (REST2 = 99), plus child passengers known to be restrained, but unknown if they were in a safety seat or just belts.

```
DATA OCC6 UNKBELT1; SET OCC5;
IF REST2=99 THEN OUTPUT UNKBELT1;
  ELSE IF 0 LE AGE LE 5 AND PER_TYP=2 AND REST2=8 THEN OUTPUT UNKBELT1;
  ELSE OUTPUT OCC6;
RUN;
```

UNKBELT1 is further subdivided into: occupants of front-outboard seats equipped with 3-point belts (UNK3PT1), with 2-point automatic belts (UNK2PT1), back seats equipped with 3-point belts (UNKBK31), any seats equipped with lap belts or separate lap and shoulder belts (UNKLAP1), child passengers age 0-5 with completely unknown restraint use (UNKKID1), and child passengers age 0-5 known to be restrained, but unknown what type of restraint (UNKKID2). FTLS = 8 is primarily 3-point belts with some 2-point, and is sent to UNK3PT1; other mixes are sent to UNKLAP1.

```
/* ---------------------------------------------------------------- */
/*  DISTRIBUTES AND IMPUTES BELT USE WHEN UNKNOWN; SEPARATELY FOR   */
/*  FRONT-SEAT 3-POINT, AUTOMATIC 2-POINT, BACK-SEAT 3-POINT, LAP,  */
/*  INFANT-TODDLER (IN 2 STEPS: USED/NOT-USED BELT/SAFETY-SEAT)     */
/*  BASED ON LOGISTIC REGRESSION MODELS FROM L3PT4, L2PT4, LBK3PT4, */
/*  L_LAP4, & LKIDRES4                                              */
/* ---------------------------------------------------------------- */

DATA UNK3PT1 UNK2PT1 UNKBK31 UNKLAP1 UNKKID1 UNKKID2;
SET UNKBELT1;
GENDER=SEX; IF GENDER NE 2 THEN GENDER=1;
IF 0 LE AGE LE 97 THEN NEWAGE=AGE; ELSE NEWAGE=30;
  IF PER_TYP=1 AND AGE LT 14 THEN NEWAGE=30;
IF 0 LE AGE LE 5 AND PER_TYP=2 AND REST2=8 THEN OUTPUT UNKKID2;
ELSE IF SEAT2=11 THEN DO;
  IF FTLS=2 THEN OUTPUT UNK2PT1;
  ELSE IF FTLS IN (3,4,8) THEN OUTPUT UNK3PT1;
  ELSE OUTPUT UNKLAP1; END;
ELSE IF SEAT2=13 THEN DO;
  IF 0 LE AGE LE 5 THEN OUTPUT UNKKID1;
  ELSE IF FTLS IN (2,4) THEN OUTPUT UNK2PT1;
  ELSE IF FTLS IN (3,8) THEN OUTPUT UNK3PT1;
  ELSE OUTPUT UNKLAP1; END;
ELSE IF SEAT2=21 THEN DO;
```

```
  IF 0 LE AGE LE 5 THEN OUTPUT UNKKID1;
  ELSE IF BKLS=3 THEN OUTPUT UNKBK31;
  ELSE OUTPUT UNKLAP1; END;
ELSE IF SEAT2=22 THEN DO;
  IF 0 LE AGE LE 5 THEN OUTPUT UNKKID1;
  ELSE IF CBKLS=3 THEN OUTPUT UNKBK31;
  ELSE OUTPUT UNKLAP1; END;
ELSE IF SEAT2=12 THEN DO;
  IF 0 LE AGE LE 5 THEN OUTPUT UNKKID1;
  ELSE OUTPUT UNKLAP1; END;
RUN;
```

The program L3PT4 is a logistic regression that calibrates belt use of front-outboard occupants in vehicles with 3-point belts, based on cases where belt use is known, as a function of the calendar year, the occupant's age and gender, the vehicle type, vehicle age, crash mode and seat position. The code here defines the independent variables used in L3PT4 and copies the regression equation obtained there, in order to impute the belt use of occupants for whom it is unknown on FARS.

```
/* IMPUTES FRONT-SEAT 3-POINT BELT USE BASED ON LOGISTIC REGRESSION EQUATION */

DATA UNK3PT2; SET UNK3PT1;
IF NEWAGE GE 17 THEN FEMALE=GENDER-1;
  ELSE IF 6 LE NEWAGE LE 13 THEN FEMALE=.5;
  ELSE IF 14 LE NEWAGE LE 16 THEN FEMALE=.5*GENDER-.25;
PRETEEN=0; TEEN=0; ADULT=0; OLD=0;
  IF 6 LE NEWAGE LE 12 THEN PRETEEN=1;
  ELSE IF 13 LE NEWAGE LE 20 THEN TEEN=20-NEWAGE;
  ELSE IF 30 LE NEWAGE LE 79 THEN ADULT=NEWAGE-30;
  ELSE IF 80 LE NEWAGE LE 97 THEN OLD=1;
CONVRTBL=0; TWODOOR=0; STAWAGON=0; UNK_CAR=0; PICKUP=0; SUV=0; VAN=0; UNK_LTRK=0;
  IF NEWVTYP=1 THEN CONVRTBL=1;
  ELSE IF NEWVTYP=2 THEN TWODOOR=1;
  ELSE IF NEWVTYP=6 THEN STAWAGON=1;
  ELSE IF NEWVTYP=9 THEN UNK_CAR=1;
  ELSE IF NEWVTYP=11 THEN PICKUP=1;
  ELSE IF NEWVTYP=12 THEN SUV=1;
  ELSE IF NEWVTYP=13 THEN VAN=1;
  ELSE IF NEWVTYP=19 THEN UNK_LTRK=1;
CY7576=0; CY7778=0; CY7980=0; CY81=0; CY82=0; CY83=0; CY84=0;
  CY85=0; CY86=0; CY87=0; CY88=0; CY89=0; CY90=0; CY91=0;
  CY92=0; CY93=0; CY94=0; CY95=0; CY96=0; CY97=0; CY98=0;
  CY2000=0; CY2001=0; CY2002=0;
IF CY IN (1975,1976) THEN CY7576=1;
  ELSE IF CY IN (1977,1978) THEN CY7778=1;
  ELSE IF CY IN (1979,1980) THEN CY7980=1;
  ELSE IF CY=1981 THEN CY81=1; ELSE IF CY=1982 THEN CY82=1;
  ELSE IF CY=1983 THEN CY83=1; ELSE IF CY=1984 THEN CY84=1;
  ELSE IF CY=1985 THEN CY85=1; ELSE IF CY=1986 THEN CY86=1;
  ELSE IF CY=1987 THEN CY87=1; ELSE IF CY=1988 THEN CY88=1;
  ELSE IF CY=1989 THEN CY89=1; ELSE IF CY=1990 THEN CY90=1;
  ELSE IF CY=1991 THEN CY91=1; ELSE IF CY=1992 THEN CY92=1;
  ELSE IF CY=1993 THEN CY93=1; ELSE IF CY=1994 THEN CY94=1;
  ELSE IF CY=1995 THEN CY95=1; ELSE IF CY=1996 THEN CY96=1;
  ELSE IF CY=1997 THEN CY97=1; ELSE IF CY=1998 THEN CY98=1;
  ELSE IF CY=2000 THEN CY2000=1; ELSE IF CY=2001 THEN CY2001=1;
  ELSE IF CY=2002 THEN CY2002=1;
RTFRONT=0; IF SEAT2=13 THEN RTFRONT=1;
SIDE=0; ROLL=0; REAROTHR=0;
  IF CRSH=2 THEN SIDE=1; ELSE IF CRSH=3 THEN ROLL=1; ELSE IF CRSH=4 THEN REAROTHR=1;
VEH_AGE=CY-MY; IF VEH_AGE LT 0 THEN VEH_AGE=0;

Z=-.2954+.7226*PRETEEN+.0292*TEEN+.0202*ADULT+.9100*OLD+.4728*FEMALE;
Z=Z-.1273*CONVRTBL-.2593*TWODOOR+.1047*STAWAGON-.0414*UNK_CAR;
```

```
Z=Z-.7998*PICKUP-.3697*SUV-.1141*VAN-.4421*UNK_LTRK-.0647*VEH_AGE;
Z=Z-2.4205*CY7576-2.9491*CY7778-3.2598*CY7980-3.3202*CY81-3.2030*CY82;
Z=Z-2.9786*CY83-2.6736*CY84-1.8587*CY85-1.3004*CY86-1.0471*CY87;
Z=Z-.9215*CY88-.8555*CY89-.7852*CY90-.6234*CY91-.4971*CY92-.3323*CY93;
Z=Z-.2301*CY94-.2192*CY95-.1221*CY96-.0760*CY97-.0047*CY98;
Z=Z+.1102*CY2000+.1544*CY2001+.2124*CY2002;
Z=Z+.4169*SIDE-.4605*ROLL+.1482*REAROTHR-.0332*RTFRONT;
```

Based on the logistic regression equation, BELTED is the probability that the occupant was belted; UNBELTED is the probability they were unrestrained. Each case with unknown belt use is split into two cases with known belt use: one yes, weighted by the probability that the occupant was belted; the other no, weighted by UNBELTED.

```
BELTED=EXP(Z)/(1+EXP(Z)); UNBELTED=1-BELTED;
O1=ORIGWT; W1=WEIGHTFA;
REST2=0; ORIGWT=UNBELTED* O1; WEIGHTFA=UNBELTED* W1; OUTPUT;
REST2=8; ORIGWT= BELTED * O1; WEIGHTFA= BELTED * W1; OUTPUT;
RUN;

/* IMPUTES AUTOMATIC 2-POINT BELT USE BASED ON LOGISTIC REGRESSION EQUATION */

DATA UNK2PT2; SET UNK2PT1;
IF PASSIVE IN (606,707,1606) THEN MOTOR=0; ELSE MOTOR=1;
IF NEWAGE GE 17 THEN FEMALE=GENDER-1;
  ELSE IF 6 LE NEWAGE LE 13 THEN FEMALE=.5;
  ELSE IF 14 LE NEWAGE LE 16 THEN FEMALE=.5*GENDER-.25;
PRETEEN=0; TEEN=0; ADULT=0; OLD=0;
  IF 6 LE NEWAGE LE 12 THEN PRETEEN=1;
  ELSE IF 13 LE NEWAGE LE 20 THEN TEEN=20-NEWAGE;
  ELSE IF 30 LE NEWAGE LE 79 THEN ADULT=NEWAGE-30;
  ELSE IF 80 LE NEWAGE LE 97 THEN OLD=1;
RTFRONT=0; IF SEAT2=13 THEN RTFRONT=1;
SIDE=0; ROLL=0; REAROTHR=0;
  IF CRSH=2 THEN SIDE=1; ELSE IF CRSH=3 THEN ROLL=1; ELSE IF CRSH=4 THEN REAROTHR=1;
VEH_AGE=CY-MY; IF VEH_AGE LT 0 THEN VEH_AGE=0;

Z=-.2911+.6194*MOTOR+.5819*PRETEEN+.0323*TEEN+.0289*ADULT+1.4860*OLD+.4928*FEMALE;
Z=Z-.0199*VEH_AGE+.1496*SIDE-.7183*ROLL-.0317*REAROTHR-.0732*RTFRONT;
BELTED=EXP(Z)/(1+EXP(Z)); UNBELTED=1-BELTED;
O1=ORIGWT; W1=WEIGHTFA;
REST2=0; ORIGWT=UNBELTED* O1; WEIGHTFA=UNBELTED* W1; OUTPUT;
REST2=8; ORIGWT= BELTED * O1; WEIGHTFA= BELTED * W1; OUTPUT;
RUN;

/* IMPUTES BACK-SEAT 3-POINT BELT USE BASED ON LOGISTIC REGRESSION EQUATION */

DATA UNKBK32; SET UNKBK31;
IF NEWAGE GE 17 THEN FEMALE=GENDER-1;
  ELSE IF 6 LE NEWAGE LE 13 THEN FEMALE=.5;
  ELSE IF 14 LE NEWAGE LE 16 THEN FEMALE=.5*GENDER-.25;
PRETEEN=0; TEEN=0; ADULT=0; OLD=0;
  IF 6 LE NEWAGE LE 12 THEN PRETEEN=1;
  ELSE IF 13 LE NEWAGE LE 20 THEN TEEN=20-NEWAGE;
  ELSE IF 30 LE NEWAGE LE 79 THEN ADULT=NEWAGE-30;
  ELSE IF 80 LE NEWAGE LE 97 THEN OLD=1;
TWODOOR=0; VAN=0; OTHR_TRK=0;
  IF NEWVTYP IN (1,2) THEN TWODOOR=1;
  ELSE IF NEWVTYP=9 THEN TWODOOR=.5;
  ELSE IF NEWVTYP IN (11,12,19) THEN OTHR_TRK=1;
  ELSE IF NEWVTYP=13 THEN VAN=1;
CY7589=0; CY9094=0; CY9599=0;
IF 1975 LE CY LE 1989 THEN CY7589=1;
  ELSE IF 1990 LE CY LE 1994 THEN CY9094=1;
  ELSE IF 1995 LE CY LE 1999 THEN CY9599=1;
```

```
SIDE=0; ROLL=0; REAROTHR=0;
  IF CRSH=2 THEN SIDE=1; ELSE IF CRSH=3 THEN ROLL=1; ELSE IF CRSH=4 THEN REAROTHR=1;
VEH_AGE=CY-MY; IF VEH_AGE LT 0 THEN VEH_AGE=0;
CENREAR=0; IF SEAT2=22 THEN CENREAR=1;

Z=-1.4715+1.5495*PRETEEN+.1042*TEEN+.0294*ADULT+1.3595*OLD+.3314*FEMALE;
Z=Z-.1506*TWODOOR+.0012*VAN-.3215*OTHR_TRK-.0303*VEH_AGE;
Z=Z-.7777*CY7589-.4001*CY9094-.2469*CY9599;
Z=Z+.2107*SIDE-.6045*ROLL+.2894*REAROTHR-.6754*CENREAR;
BELTED=EXP(Z)/(1+EXP(Z)); UNBELTED=1-BELTED;
O1=ORIGWT; W1=WEIGHTFA;
REST2=0; ORIGWT=UNBELTED* O1; WEIGHTFA=UNBELTED* W1; OUTPUT;
REST2=8; ORIGWT= BELTED * O1; WEIGHTFA= BELTED * W1; OUTPUT;
RUN;

/* IMPUTES LAP BELT USE BASED ON LOGISTIC REGRESSION EQUATION */

DATA UNKLAP2; SET UNKLAP1;
PRE_STD=0;
  IF SEAT2 IN (11,13) AND MY LT 1964 THEN PRE_STD=1;
    ELSE IF SEAT2=21 AND MY LT 1966 THEN PRE_STD=1;
    ELSE IF SEAT2 IN (12,22) AND MY LT 1968 THEN PRE_STD=1;
IF NEWAGE GE 17 THEN FEMALE=GENDER-1;
  ELSE IF 6 LE NEWAGE LE 13 THEN FEMALE=.5;
  ELSE IF 14 LE NEWAGE LE 16 THEN FEMALE=.5*GENDER-.25;
PRETEEN=0; TEEN=0; ADULT=0; OLD=0;
  IF 6 LE NEWAGE LE 12 THEN PRETEEN=1;
  ELSE IF 13 LE NEWAGE LE 20 THEN TEEN=20-NEWAGE;
  ELSE IF 30 LE NEWAGE LE 79 THEN ADULT=NEWAGE-30;
  ELSE IF 80 LE NEWAGE LE 97 THEN OLD=1;
TWODOOR=0; PICKUP=0; SUV_VAN=0;
  IF NEWVTYP IN (1,2) THEN TWODOOR=1;
  ELSE IF NEWVTYP=9 THEN TWODOOR=.63;
  ELSE IF NEWVTYP=11 THEN PICKUP=1;
  ELSE IF NEWVTYP IN (12,13) THEN SUV_VAN=1;
  ELSE IF NEWVTYP=19 THEN DO; PICKUP=.72; SUV_VAN=.28; END;
CY7579=0; CY8084=0; CY8589=0; CY9094=0; CY9599=0;
IF 1975 LE CY LE 1979 THEN CY7579=1;
  ELSE IF 1980 LE CY LE 1984 THEN CY8084=1;
  ELSE IF 1985 LE CY LE 1989 THEN CY8589=1;
  ELSE IF 1990 LE CY LE 1994 THEN CY9094=1;
  ELSE IF 1995 LE CY LE 1999 THEN CY9599=1;
CENFRONT=0; RTFRONT=0; OUTBRD_R=0; CENREAR=0;
  IF SEAT2=12 THEN CENFRONT=1;
  ELSE IF SEAT2=13 THEN RTFRONT=1;
  ELSE IF SEAT2=21 THEN OUTBRD_R=1;
  ELSE IF SEAT2=22 THEN CENREAR=1;
SIDE=0; ROLL=0; REAROTHR=0;
  IF CRSH=2 THEN SIDE=1; ELSE IF CRSH=3 THEN ROLL=1; ELSE IF CRSH=4 THEN REAROTHR=1;
VEH_AGE=CY-MY; IF VEH_AGE LT 0 THEN VEH_AGE=0;

Z=-.3189+1.1862*PRETEEN+.0323*TEEN+.0204*ADULT+1.1997*OLD;
Z=Z-.2945*PRE_STD-1.2292*CENFRONT-.1795*RTFRONT-.7338*OUTBRD_R-1.6522*CENREAR;
Z=Z+.4191*FEMALE-.0717*TWODOOR-.8322*PICKUP-.0642*SUV_VAN-.0535*VEH_AGE;
Z=Z-3.0443*CY7579-3.2209*CY8084-1.4020*CY8589-.7785*CY9094-.3090*CY9599;
Z=Z+.0432*SIDE-.1522*ROLL+.0675*REAROTHR;
BELTED=EXP(Z)/(1+EXP(Z)); UNBELTED=1-BELTED;
O1=ORIGWT; W1=WEIGHTFA;
REST2=0; ORIGWT=UNBELTED* O1; WEIGHTFA=UNBELTED* W1; OUTPUT;
REST2=8; ORIGWT= BELTED * O1; WEIGHTFA= BELTED * W1; OUTPUT;
RUN;
```

The imputation procedure for child passengers age 0-5 is performed in two steps. First, each case with completely unknown restraint use is split into two cases based on the first logistic regression

equation in LKIDRES4: one unrestrained, one restrained, type unknown. Next, the restrained cases generated from this procedure, plus the already existing cases of children that were restrained, type unknown are split into two cases based on the second equation in LKIDRES4: one in a safety seat, one in a lap belt only.

```
/* IMPUTES RESTRAINED AND UNRESTRAINED INFANTS/TODDLERS */

DATA UNKKID3 UNKKID4; SET UNKKID1 UNKKID2(IN=KID2);
INFANT=0; AGE1=0; AGE2=0; AGE3=0; AGE4=0;
  IF NEWAGE=0 THEN INFANT=1; ELSE IF NEWAGE=1 THEN AGE1=1;
  ELSE IF NEWAGE=2 THEN AGE2=1; ELSE IF NEWAGE=3 THEN AGE3=1;
  ELSE IF NEWAGE=4 THEN AGE4=1;
IF VTYP=2 THEN LTRK=1; ELSE LTRK=0;
CY7576=0; CY7778=0; CY7980=0; CY81=0; CY82=0; CY83=0; CY84=0;
  CY85=0; CY86=0; CY87=0; CY88=0; CY89=0; CY90=0; CY91=0;
  CY92=0; CY93=0; CY94=0; CY95=0; CY96=0; CY97=0; CY98=0;
  CY2000=0; CY2001=0; CY2002=0;
IF CY IN (1975,1976) THEN CY7576=1;
  ELSE IF CY IN (1977,1978) THEN CY7778=1;
  ELSE IF CY IN (1979,1980) THEN CY7980=1;
  ELSE IF CY=1981 THEN CY81=1; ELSE IF CY=1982 THEN CY82=1;
  ELSE IF CY=1983 THEN CY83=1; ELSE IF CY=1984 THEN CY84=1;
  ELSE IF CY=1985 THEN CY85=1; ELSE IF CY=1986 THEN CY86=1;
  ELSE IF CY=1987 THEN CY87=1; ELSE IF CY=1988 THEN CY88=1;
  ELSE IF CY=1989 THEN CY89=1; ELSE IF CY=1990 THEN CY90=1;
  ELSE IF CY=1991 THEN CY91=1; ELSE IF CY=1992 THEN CY92=1;
  ELSE IF CY=1993 THEN CY93=1; ELSE IF CY=1994 THEN CY94=1;
  ELSE IF CY=1995 THEN CY95=1; ELSE IF CY=1996 THEN CY96=1;
  ELSE IF CY=1997 THEN CY97=1; ELSE IF CY=1998 THEN CY98=1;
  ELSE IF CY=2000 THEN CY2000=1; ELSE IF CY=2001 THEN CY2001=1;
  ELSE IF CY=2002 THEN CY2002=1;
IF SEAT2 IN (12,13,21,22);
  CENFRONT=0; RTFRONT=0; CENREAR=0;
  IF SEAT2=12 THEN CENFRONT=1;
  ELSE IF SEAT2=13 THEN RTFRONT=1;
  ELSE IF SEAT2=22 THEN CENREAR=1;
SIDE=0; ROLL=0; REAROTHR=0;
  IF CRSH=2 THEN SIDE=1; ELSE IF CRSH=3 THEN ROLL=1; ELSE IF CRSH=4 THEN REAROTHR=1;

IF KID2 THEN DO; OUTPUT UNKKID4; RETURN; END;
ELSE DO;
Z=.3711+.7837*INFANT+.8726*AGE1+.5193*AGE2+.1485*AGE3+.1024*AGE4;
Z=Z-.0472*LTRK-3.4784*CY7576-3.5735*CY7778-3.0285*CY7980;
Z=Z-2.7536*CY81-2.4664*CY82-2.0078*CY83-1.5532*CY84-1.1660*CY85;
Z=Z-1.1936*CY86-1.0132*CY87-1.0726*CY88-1.0026*CY89- .9834*CY90;
Z=Z-.7092*CY91-.5285*CY92-.6801*CY93-.3309*CY94-.2090*CY95;
Z=Z-.0455*CY96-.0201*CY97+.0808*CY98;
Z=Z+.2306*CY2000+.1098*CY2001+.1525*CY2002;
Z=Z+.2874*SIDE-.5541*ROLL-.2060*REAROTHR;
Z=Z-1.4496*CENFRONT-.7022*RTFRONT-.7946*CENREAR;
BELTED=EXP(Z)/(1+EXP(Z)); UNBELTED=1-BELTED;
O1=ORIGWT; W1=WEIGHTFA;
REST2=0; ORIGWT=UNBELTED* O1; WEIGHTFA=UNBELTED* W1; OUTPUT UNKKID3;
REST2=8; ORIGWT= BELTED * O1; WEIGHTFA= BELTED * W1; OUTPUT UNKKID4; END;
RUN;

/* IMPUTES IF THE RESTRAINED INFANTS/TODDLERS WERE IN CHILD SEATS OR LAP BELTS */

DATA UNKKID5; SET UNKKID4;
Z=-1.6869+5.6002*INFANT+4.5930*AGE1+3.4650*AGE2+2.7264*AGE3+1.2914*AGE4;
Z=Z-.0439*LTRK-1.2118*CY7576-1.5049*CY7778-1.0482*CY7980;
Z=Z- .9440*CY81- .5881*CY82- .2602*CY83- .3824*CY84- .3179*CY85;
Z=Z- .9094*CY86- .8220*CY87-1.1240*CY88- .7704*CY89- .4048*CY90;
Z=Z-.2422*CY91-.1682*CY92-.6909*CY93-.7306*CY94-.4925*CY95;
```

```
Z=Z-.4550*CY96-.3514*CY97-.6729*CY98;
Z=Z+.1257*CY2000-.1710*CY2001+.0451*CY2002;
Z=Z+.0723*SIDE+.0479*ROLL+.2250*REAROTHR;
Z=Z-.7766*CENFRONT-1.0595*RTFRONT+.0752*CENREAR;
KIDSEAT=EXP(Z)/(1+EXP(Z)); LAPBELT=1-KIDSEAT;
O1=ORIGWT; W1=WEIGHTFA;
REST2=2; ORIGWT=LAPBELT * O1; WEIGHTFA=LAPBELT * W1; OUTPUT;
REST2=4; ORIGWT=KIDSEAT * O1; WEIGHTFA=KIDSEAT * W1; OUTPUT;
RUN;
```

UNKBELT2 contains all the newly created cases with known restraint use. It is appended to OCC6, the original cases with known restraint use, creating OCC7, a file on which all cases have known restraint use (and seat positions and crash modes).

```
DATA UNKBELT2;
SET UNK3PT2 UNK2PT2 UNKBK32 UNKLAP2 UNKKID3 UNKKID5;
DROP GENDER NEWAGE Z BELTED UNBELTED O1 W1 PRETEEN TEEN ADULT OLD FEMALE
  CONVRTBL TWODOOR STAWAGON UNK_CAR PICKUP SUV VAN UNK_LTRK
  VEH_AGE CY7576 CY7778 CY7980 CY81-CY98 CY2000 CY2001 SIDE ROLL REAROTHR RTFRONT
  MOTOR OTHR_TRK CY7589 CY9094 PRE_STD CENFRONT OUTBRD_R CENREAR SUV_VAN
  CY7579 CY8084 CY8589 KIDSEAT LAPBELT;
RUN;
```

REST3 edits REST2, assigning a specific restraint type to every restrained occupant on the file (and REST3 = 0 for unrestrained occupants).

- Every restrained child age 0-5 is either in a child safety seat (REST3 = 4) or in a lap belt (REST3 = 2), without distinguishing if the seat was correctly used; even if the belt is a 3-point belt, it will be considered "lap belt only" for children that age.
- Children age 6-9 that FARS explicitly states were in child safety seats (REST_USE = 4) will be considered in booster seats (REST3 = 4). All other children age 6-9 will be included with "adults" in the remaining categories.
- Every restrained adult in a seat equipped with integral (manual or automatic) 3-point belts will be considered as restrained with a 3-point belt (REST3 = 3), without distinguishing that some of these may have been incorrectly worn and, in effect, acted like just a lap belt.
- Every restrained adult in a seat equipped with automatic 2-point belts will be considered as restrained with a 2-point belt (REST3 = 7), without distinguishing between people who also wore the manual lap belt, if one was available, and those who didn't.
- In seats equipped with separate lap and shoulder belts, restrained adults will only be considered as having worn both belts (REST3 = 3) if FARS explicitly stated that the lap and shoulder belts were used (REST_USE = 3). All other restrained adults, including the imputed cases will be assumed to have worn only the lap belt (REST3 = 2). These assumptions are most consistent with observational surveys that showed separate shoulder belts were only used by about 15-25 percent of the people who buckled the lap belt.
- Restrained adults in 1975-80 VW Rabbits – vehicles where it is impossible to tell if they had 3-point or 2-point belts, but the 3-point belts were more common – will only be considered as 2-point belted if REST_USE = 1,8 or AUT_REST = 1,5.
- And, of course, in seats equipped only with lap belts, restrained adults will be considered lap-belted.

```
/* ------------------------------------------------------------- */
/*  EVERY OCCUPANT CASE IS NOW ASSIGNED A SPECIFIC BELT TYPE     */
/*  (OR UNRESTRAINED) ACCORDING TO REST2, SEAT2, FTLS, BKLS, & CBKLS  */
```

```
/* ---------------------------------------------------------------- */

DATA OCC7; SET OCC6 UNKBELT2;
IF REST2 IN (0,4) THEN REST3=REST2;
  ELSE IF 0 LE AGE LE 5 THEN REST3=2;
  ELSE IF SEAT2=12 THEN REST3=2;
  ELSE IF SEAT2=22 AND CBKLS=3 THEN REST3=3;
  ELSE IF SEAT2=22 THEN REST3=2;
  ELSE IF SEAT2=21 AND BKLS=3 THEN REST3=3;
  ELSE IF SEAT2=21 THEN REST3=2;
  ELSE IF FTLS=3 THEN REST3=3;
  ELSE IF FTLS=2 THEN REST3=7;
  ELSE IF FTLS=1 THEN REST3=2;
  ELSE IF FTLS=4 AND SEAT2=11 THEN REST3=3;
  ELSE IF FTLS=4 AND SEAT2=13 THEN REST3=7;
  ELSE IF FTLS IN (5,6,7) AND REST2=3 THEN REST3=3;
  ELSE IF FTLS IN (5,6,7) THEN REST3=2;
  ELSE IF FTLS=8 AND REST2 IN (1,7,8) THEN REST3=7;
  ELSE IF FTLS=8 THEN REST3=3;
```

The two variables RESTGP and KCRSH are used for estimating the effect of air bags on the risk of a child passenger.

```
/* ---------------------------------------------------------------- */
/*  CLASSIFICATION OF RF CHILD PASSENGERS EXPOSED TO AIR BAGS       */
/* ---------------------------------------------------------------- */

IF 0 LE AGE LE 12 AND SEAT2=13 AND PASSIVE IN (2,3,1313) THEN DO;
  IF AGE=0 AND REST3=4 THEN RESTGP=1;
    ELSE IF AGE=0 AND REST3 IN (0,2,3,7) THEN RESTGP=2;
    ELSE IF 1 LE AGE LE 5 AND REST3=0 THEN RESTGP=3;
    ELSE IF 1 LE AGE LE 5 AND REST3=4 THEN RESTGP=4;
    ELSE IF 1 LE AGE LE 5 AND REST3 IN (2,3,7) THEN RESTGP=5;
    ELSE IF 6 LE AGE LE 10 AND REST3=0 THEN RESTGP=6;
    ELSE IF 6 LE AGE LE 10 AND REST3 IN (2,3,4,7) THEN RESTGP=7;
    ELSE IF 11 LE AGE LE 12 AND REST3=0 THEN RESTGP=8;
    ELSE IF 11 LE AGE LE 12 AND REST3 IN (2,3,7) THEN RESTGP=9;

  IF IMPACT2=12 OR IMPACT1=12 THEN KCRSH=1;
      ELSE IF IMPACT2 IN (1,11) OR IMPACT1 IN (1,11) THEN KCRSH=2;
      ELSE IF IMPACT2 IN (2,10) OR IMPACT1 IN (2,10) THEN KCRSH=3;
      ELSE KCRSH=4; END;
RUN;
```

This completes the preprocessor. OCC7 is a file in which every record has non-missing values for all the variables needed to estimate lives saved by safety technologies, and whose ORIGWTs (and WEIGHTFAs) add up to the total number of car and LTV occupant fatalities in 1975-2002.

```
/* ---------------------------------------------------------------- */
/*  SPLIT THE CAR AND LIGHT-TRUCK OCCUPANT CASES INTO SEPARATE FILES  */
/* ---------------------------------------------------------------- */
```

OCC7 is split into CAR1 and TRK1 because the main model is run separately for cars and for LTVs (because the safety technologies were introduced in a different chronological order, and the effectiveness is sometimes different in cars and LTVs). Also, the preprocessor changed the order of the cases because the imputed cases were, at each step, appended at the end of the file. In order to tally up lives saved by calendar year, it is necessary to sort CAR1 and TRK1 by CY.

```
DATA CAR1 TRK1; SET OCC7;
IF VTYP=1 THEN OUTPUT CAR1; ELSE OUTPUT TRK1;
RUN;
```

```
PROC SORT DATA=CAR1; BY CY;
PROC SORT DATA=TRK1; BY CY;
RUN;

/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
/*  THE OCCUPANT CASES ARE NOW FREE OF UNKNOWNS ON ANY VARIABLES      */
/*  AND WEIGHTED TO TOTAL UP TO THE ORIGINAL SAMPLE SIZE              */
/*                                                                    */
/*  WE MAY NOW CALCULATE THE LIVES SAVED BY THE VEHICLE SAFETY        */
/*  STANDARDS IN THE REVERSE ORDER OF THEIR IMPLEMENTATION            */
/*                                                                    */
/*  PASSENGER CARS FIRST                                              */
```

When the notes mention "NHTSA evaluations" and "effectiveness estimates," they are generally discussed in Part 1 of this report, in the chapter for that FMVSS and subsection for that technology. Footnotes/references are provided here only for analyses not discussed in Part 1.

```
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
```

Three "tags" of information accompany each case as it processes through the model:

- ORIGWT, the original case weight defined by the preprocessor, remains unchanged in the main model.
- WEIGHTFA, the inflated case weight, grows as safety technologies are "removed" from the vehicle. The existence of ORIGWT fatalities in a vehicle equipped with safety technologies implies that there would have been WEIGHTFA fatalities if the vehicle had no safety technologies at all, in the sense that the combined effectiveness of these technologies would reduce WEIGHTFA fatalities to ORIGWT fatalities.
- EJECT2, the probability that an occupant was ejected. Initially, EJECT2 is either 1 (if the occupant was ejected) or 0 (if not ejected or unknown[1]). However, some safety technologies, such as belts, can reduce the probability of ejection, whereas other technologies, such as improved door locks, are effective only if the occupant was ejected. Thus, it is necessary to track the occupant's changing probability of ejection as technologies are removed from the vehicle one-by-one.

```
DATA CAR2; SET CAR1;
IF EJECTION IN (1,2) THEN EJECT2=1; ELSE EJECT2=0;
```

Three-point belts for rear-center occupants, already widely available in cars in anticipation of Anton's Law, are the most recent safety technology for which an effectiveness estimate is available, so they will be the first technology that the model "removes" from the car. The basic procedure of the model was discussed in detail, above, in the analysis the effect of brake improvements on pedestrian crashes.

```
/* ------------------------------------------------------------------ */
/*  208J 3-POINT BELTS FOR BACK-SEAT CENTER OCCUPANTS (ANTON'S LAW)   */
/*  MEDIAN INSTALLATION YEAR: 2001                                    */
/* ------------------------------------------------------------------ */
```

[1] Tabulation of EJECTION by calendar year suggests that, in the early years, especially 1975-76, "unknown" essentially means not ejected. From 1985 onward, well under 1 percent are unknown if ejected.

Unlike the situation with brakes, we know what specific occupants are protected by rear-center 3-point belts. In other words, PV208J or PS208J are not probabilities between 0 and 1, but are either exactly 0 or exactly 1. Moreover, because it is still before the effective date of the regulation specified by Anton's Law, PS208J = 0 in 1975-2002, and only PV208J can equal 1. PV208J = 1 if the occupant was age 6+, sat in a rear-center seat equipped with 3-point belts, and wore those belts, and PV208J = 0 for all other occupants.

```
/* IDENTIFIES BACK-SEAT OCCUPANTS WEARING 3-POINT BELTS  */
  PS208J=0; PV208J=0;
  IF SEAT2=22 AND REST3=3 THEN DO; IF MY LE 2008 THEN PV208J=1; ELSE PS208J=1; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY BACK-SEAT CENTER 3-POINT BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208J GT 0 OR PV208J GT 0 THEN DO;
```

The data in NHTSA's evaluation of 3-point belts in the rear-outboard seats indicate fatality reduction of 29 percent in frontals, 42 percent in side impacts, 77 percent in rollovers and 31 percent in rear/other impacts. We will assume the same effectiveness for 3-point belts in the rear-center seat. Moreover, when we "remove" the belts from the vehicle, the occupant becomes unrestrained and, in general, 26 percent of unrestrained rear-center occupant fatalities in frontal crashes were ejected, 33 percent in side impacts, 64 percent in rollovers and 31 percent in rear/other impacts. One of these becomes the new values of EJECT2 as this now-unrestrained occupant fatality case proceeds through the rest of the model.

CLV208J: "C" = car, "L" = lives saved, "V" = voluntary, "208J" = rear-center 3-point belt

```
    IF CRSH=1 THEN DO; E=.29; EJECT2=.26; END;
      ELSE IF CRSH=2 THEN DO; E=.42; EJECT2=.33; END;
      ELSE IF CRSH=3 THEN DO; E=.77; EJECT2=.64; END;
      ELSE IF CRSH=4 THEN DO; E=.31; EJECT2=.31; END;
    P=PS208J+PV208J;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208J=S*PS208J/P;
    CLV208J=S*PV208J/P;
    WEIGHTFA=OLDWTFA+CLS208J+CLV208J; END;
  ELSE DO; CLS208J=0; CLV208J=0; END;
  CL208J=CLS208J+CLV208J;
  CLS=CLS208J; CLV=CLV208J; CL=CL208J;
```

By the way, when this model "removes" a 3-point belt system from the vehicle, it removes the entire system, not just the shoulder harness. The occupant from this point onwards is unrestrained, not lap-belted. The lives saved by the 3-point system are the benefits of that system relative to being unrestrained, not the incremental benefit of a 3-point system relative to lap belts only. This model includes nine belt technologies (208A, 208B, 208C, 208D, 208E, 208F, 208G, 208H and 208J), but no more than one can apply to any specific occupant case.[2]

```
/* ------------------------------------------------------------------ */
/*  108 TRAILER CONSPICUITY TAPE (LIVES SAVED IN CARS NOT HITTING THEM) */
/*  50% OF TRAILERS ON THE ROAD HAD THEM IN: 1996                      */
```

[2] It would also have been theoretically possible to estimate the effectiveness of 3-point belts relative to lap belts only (rather than relative to being unrestrained), and then have the model subdivide the lives saved by 3-point belts into (1) lives that would have been saved even by just a lap belt (and count them under technology 208A) and (2) lives that were saved only because there was also a shoulder harness (and count only these in technology 208F). This approach would probably be confusing, since it would attribute a large number of saves to lap belts who were, in fact, people that used 3-point belts.

```
/*  FMCSA RETROFIT REQUIREMENT ISSUED 3/31/1999, TOOK EFFECT 6/1/2001   */
/* ------------------------------------------------------------------- */

/* IDENTIFIES SIDE/REAR IMPACTS INTO TRAILERS IN THE DARK AND % OF TRAILERS WITH TAPE */
  PS108=0; PV108=0;
```

Identifies cases where the front of a car hit the side or rear of a heavy trailer in the dark.

```
  IF CY GE 1991 AND (TAPECASE=1 OR (OVTYP=3 AND
    ((1991 LE CY LE 1994 AND OVCONFIG=5) OR (CY GE 1995 AND OVCONFIG=6))
    AND 2 LE LGT_COND LE 5 AND
      (OIMPACT2 IN (14,16) AND MAN_COLL IN (1,4,5) AND IMPACT2 IN (11,12,1))))
    THEN DO;
```

Unlike all the other safety technologies, the tape is not on the case vehicle (the car) but on the other vehicle (the heavy trailer). The model year of the case vehicle is irrelevant. The model year of the trailer is not reported on FARS. It is unknown (before June 1, 2001, the effective date of the FMCSA retrofit requirement) if this specific trailer was equipped with tape, but we can infer, from the calendar year of the crash, the probability that it was equipped with tape. PS108 is the percentage of trailers on the road that FMVSS 108 requires to be equipped with tape when new (if built after 12/1/1993) plus the percent required by the FMCSA retrofit rule (after 6/1/2001). PV108 is the percentage of trailers on the road that were built before 12/1/1993 and voluntarily fitted or retrofitted with tape, before 6/1/2001.

```
      IF CY=1991 THEN DO; PS108=0; PV108=.09; END;
        ELSE IF CY=1992 THEN DO; PS108=0; PV108=.18; END;
        ELSE IF CY=1993 THEN DO; PS108=0; PV108=.27; END;
        ELSE IF CY=1994 THEN DO; PS108=.09; PV108=.27; END;
        ELSE IF CY=1995 THEN DO; PS108=.18; PV108=.27; END;
        ELSE IF CY=1996 THEN DO; PS108=.27; PV108=.27; END;
        ELSE IF CY=1997 THEN DO; PS108=.36; PV108=.27; END;
        ELSE IF CY=1998 THEN DO; PS108=.45; PV108=.27; END;
        ELSE IF CY=1999 THEN DO; PS108=.54; PV108=.27; END;
        ELSE IF CY=2000 THEN DO; PS108=.63; PV108=.27; END;
        ELSE IF CY=2001 THEN DO; PS108=.8775; PV108=.1125; END;
        ELSE IF CY GE 2002 THEN DO; PS108=1; PV108=0; END; END;
/* CAR OCCUPANT LIVES SAVED BY CONSPICUITY TAPE ON TRUCK TRAILERS */
  OLDWTFA=WEIGHTFA;
  IF PS108 GT 0 OR PV108 GT 0 THEN DO;
```

The tape is estimated to reduce fatal impacts into the side/rear of trailers, in the dark, by 29 percent.

```
    E=.29;
    P=PS108+PV108;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS108=S*PS108/P;
    CLV108=S*PV108/P;
    WEIGHTFA=OLDWTFA+CLS108+CLV108; END;
  ELSE DO; CLS108=0; CLV108=0; END;
  CL108=CLS108+CLV108;
  CLS=CLS+CLS108; CLV=CLV+CLV108; CL=CL+CL108;

/* ------------------------------------------------------------------- */
/*  208I FRONTAL AIR BAGS FOR DRIVERS AND RF PASSENGERS AGE 13+        */
/*  MEDIAN INSTALLATION YEAR: 1994                                     */
/* ------------------------------------------------------------------- */

/* IDENTIFIES CARS WITH AIR BAGS  */
  PS208I=0; PV208I=0; UDAB=0; UPAB=0;
```

"PASSIVE," the variable that indicates the types of occupant protection at the front-outboard seats, is only defined if FARS has at least a partial VIN to decode. However, even when there is no VIN at all, we can often infer from the model year and the make if the car had driver and/or passenger air bags. All cars from MY 1997 onwards have had dual air bags. Some makes had driver air bags on all of their cars (UDAB = 1) or passenger air bags (UPAB = 1) before 1997.

```
/* CARS WITH UNKNOWN "PASSIVE" (BAD VINs) CLASSIFIED BY MAKE AND MODEL YEAR */

  IF CY GE 1985 AND MY GE 1986 AND (PASSIVE=. OR PASSIVE=9999) AND SEAT2 IN (11,13) THEN DO;
    IF SEAT2=11 THEN DO;
      IF (MAKE=42 AND MY GE 1986)
      OR (MAKE IN (13,38,45,47,51,59) AND MY GE 1990)
      OR (MAKE IN (6,32,34) AND MY GE 1991)
      OR (MAKE=37 AND MY GE 1992)
      OR (MAKE IN (19,24,39,49) AND MY GE 1993)
      OR (MAKE IN (18,21,54,58) AND MY GE 1994)
      OR (MAKE IN (9,10,12,14,20,22,30,35,41,48,52,53) AND MY GE 1995)
      OR (MAKE IN (55,63) AND MY GE 1996)
      OR MY GE 1997 THEN UDAB=1; END;

    ELSE IF SEAT2=13 THEN DO;
      IF (MAKE=45 AND MY GE 1990)
      OR (MAKE=13 AND MY GE 1993)
      OR (MAKE IN (19,32,37,42,51,54,58,59) AND MY GE 1994)
      OR (MAKE IN (6,10,12,14,24,30,34,35,39,41,47,48,52,53) AND MY GE 1995)
      OR (MAKE IN (9,22,49,55,63) AND MY GE 1996)
      OR MY GE 1997 THEN UPAB=1; END; END;
```

These are the codes of PASSIVE, based on VIN analysis, that indicate a car is equipped with frontal air bags and the driver or right-front seats, respectively. PS208I includes any installation from MY 1987 onwards, because the phase-in of automatic occupant protection began on September 1, 1986.

```
  IF CY GE 1984 AND MY GE 1985 AND
    (SEAT2=11 AND
        (PASSIVE IN (1,1003,1004,1006,2,1090,1099,1303,1313,1404,1505,1606) OR UDAB=1))
    OR (SEAT2=13 AND (PASSIVE IN (2,1313) OR UPAB=1)) THEN DO;
      IF 1985 LE MY LE 1986 THEN PV208I=1;
        ELSE IF MY GE 1987 THEN PS208I=1; END;

/* ------------------------------------------------------------------ */
/*  SPLITS CASES INTO SCENARIOS DEPENDING ON AIR BAG TYPE,            */
/*  SEAT POSITION, OCCUPANT AGE, RESTRAINT USE                        */
/*  COMPUTES LIVES SAVED BY AIR BAGS IN EACH SCENARIO                 */
/* ------------------------------------------------------------------ */
```

For car occupants, there are five different effectiveness scenarios – belted drivers, unbelted drivers, child passengers, belted adult (age 13+) passengers, and unbelted adult passengers – plus the default scenario, no air bag. Within each scenario, there are several effectiveness estimates.

```
  IF PS208I=0 AND PV208I=0 THEN GOTO CNOBAG;                /* NO AIR BAG */
    ELSE IF SEAT2=11 AND REST3 GT 0 THEN GOTO CDRVBELT;     /* BELTED DRIVER */
    ELSE IF SEAT2=11 THEN GOTO CDRVUNR;                     /* UNRESTRAINED DRIVER */
    ELSE IF 0 LE AGE LE 12 THEN GOTO CKID;                  /* CHILD RF NO SWITCH */
    ELSE IF REST3 GT 0 THEN GOTO CRFBELT;                   /* BELTED ADULT RF NO SWITCH */
    ELSE GOTO CRFUNR;                                       /* UNBELTED ADULT RF NO SWITCH */
```

In addition to the basic statistics, WEIGHTFA, CLS208I, CLV208I and CL208I, the model compiles more detailed information on air bags:

- CABDRV = car driver lives saved by air bags
- CABRF = adult (age 13+) passenger lives saved by air bags in cars
- CABKID = effect of air bags on child (age 0-12) passengers in cars; if this is a fatality increase, it will show up as a negative number.

```
CNOBAG:    CLS208I=0; CLV208I=0; CL208I=0;
    CABDRV=0; CABRF=0; CABKID=0; GOTO C214;

CDRVBELT:  OLDWTFA=WEIGHTFA;
```

Air bag effectiveness: the data from NHTSA's evaluation indicates that air bags reduce fatalities:

- In all crashes, for all drivers by 12.4 percent, for belted drivers by 10.8 percent, and for unbelted drivers by 14.0 percent.
- In frontal and partially frontal crashes, without a most-harmful-event rollover, fire or immersion, for all drivers, by 29.0 percent if the principal impact is 12:00, by 15.2 percent if it is 11:00 or 1:00, and by 5.8 percent if it is 10:00 or 2:00
- In 12:00 crashes, for all adult right-front passengers, by 31.9 percent.

There are not enough data to get precise individual estimates such as, for belted RF passengers in 11:00 or 1:00 crashes. Instead, ratios of the preceding estimates are used. For example, the effect of air bags for belted drivers in 12:00 crashes is estimated to be (.108/.124) x .290 = .25258. For belted RF passengers it would be (.319/.290) x (.108/.124) x .290 = .27784.

```
    IF 1 LE M_HARM LE 6 THEN E=0;
      ELSE IF IMPACT2=12 THEN E=.25258;
      ELSE IF IMPACT2 IN (1,11) THEN E=.13239;
      ELSE IF IMPACT2 IN (2,10) THEN E=.05052; ELSE E=0;
    P=PS208I+PV208I;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208I=S*PS208I/P;
    CLV208I=S*PV208I/P;
    WEIGHTFA=OLDWTFA+CLS208I+CLV208I;
    CL208I=CLS208I+CLV208I;
    CLS=CLS+CLS208I; CLV=CLV+CLV208I; CL=CL+CL208I;
    CABDRV=CL208I; CABRF=0; CABKID=0; GOTO C214;

CDRVUNR:   OLDWTFA=WEIGHTFA;
    IF 1 LE M_HARM LE 6 THEN E=0;
      ELSE IF IMPACT2=12 THEN E=.32742;
      ELSE IF IMPACT2 IN (1,11) THEN E=.17161;
      ELSE IF IMPACT2 IN (2,10) THEN E=.06548; ELSE E=0;
    P=PS208I+PV208I;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208I=S*PS208I/P;
    CLV208I=S*PV208I/P;
    WEIGHTFA=OLDWTFA+CLS208I+CLV208I;
    CL208I=CLS208I+CLV208I;
    CLS=CLS+CLS208I; CLV=CLV+CLV208I; CL=CL+CL208I;
    CABDRV=CL208I; CABRF=0; CABKID=0; GOTO C214;

CRFBELT:   OLDWTFA=WEIGHTFA;
    IF 1 LE M_HARM LE 6 THEN E=0;
      ELSE IF IMPACT2=12 THEN E=.27784;
      ELSE IF IMPACT2 IN (1,11) THEN E=.14563;
      ELSE IF IMPACT2 IN (2,10) THEN E=.05557; ELSE E=0;
```

```
    P=PS208I+PV208I;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208I=S*PS208I/P;
    CLV208I=S*PV208I/P;
    WEIGHTFA=OLDWTFA+CLS208I+CLV208I;
    CL208I=CLS208I+CLV208I;
    CLS=CLS+CLS208I; CLV=CLV+CLV208I; CL=CL+CL208I;
    CABDRV=0; CABRF=CL208I; CABKID=0; GOTO C214;
CRFUNR:    OLDWTFA=WEIGHTFA;
    IF 1 LE M_HARM LE 6 THEN E=0;
      ELSE IF IMPACT2=12 THEN E=.36016;
      ELSE IF IMPACT2 IN (1,11) THEN E=.18877;
      ELSE IF IMPACT2 IN (2,10) THEN E=.07203; ELSE E=0;
    P=PS208I+PV208I;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208I=S*PS208I/P;
    CLV208I=S*PV208I/P;
    WEIGHTFA=OLDWTFA+CLS208I+CLV208I;
    CL208I=CLS208I+CLV208I;
    CLS=CLS+CLS208I; CLV=CLV+CLV208I; CL=CL+CL208I;
    CABDRV=0; CABRF=CL208I; CABKID=0; GOTO C214;

CKID:      OLDWTFA=WEIGHTFA;
```

As stated in Part 1 of this report, in 12:00 impacts, air bags increased the fatality risk of infants in rear-facing seats by about 450 percent, for unrestrained children age 0-5 by about 100 percent, and for restrained children age 1-5 and unrestrained children age 6-10 by about 70 percent. In partially frontal crashes (10, 11, 1, or 2:00), the effect of air bags is about 38 percent as large as in 12:00 impacts. These estimates are based on MY 1985-2000 vehicles in 1986-2000 FARS data. Most, but not all of the vehicles pre-dated the 1998-99 redesign of air bags to reduce risk to out-of-position occupants.

```
      IF KCRSH=1 AND RESTGP=1 THEN E=-4.5;
        ELSE IF KCRSH=1 AND RESTGP IN (2,3) THEN E=-1;
        ELSE IF KCRSH=1 AND RESTGP IN (4,5,6) THEN E=-.70;
        ELSE IF KCRSH IN (2,3) AND RESTGP=1 THEN E=-1.71;
        ELSE IF KCRSH IN (2,3) AND RESTGP IN (2,3) THEN E=-.38;
        ELSE IF KCRSH IN (2,3) AND RESTGP IN (4,5,6) THEN E=-.27;
        ELSE E=0;
    P=PS208I+PV208I;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208I=S*PS208I/P;
    CLV208I=S*PV208I/P;
    WEIGHTFA=OLDWTFA+CLS208I+CLV208I;
    CL208I=CLS208I+CLV208I;
    CLS=CLS+CLS208I; CLV=CLV+CLV208I; CL=CL+CL208I;
    CABDRV=0; CABRF=0; CABKID=CL208I; GOTO C214;

/* ------------------------------------------------------------------ */
/*  214B VOLUNTARY TTI(d) REDUCTIONS IN 2-DOOR CARS                   */
/*  MEDIAN IMPLEMENTATION YEAR: 1993                                  */
/* ------------------------------------------------------------------ */

/* IDENTIFIES 2-DOOR CARS WITH VOLUNTARY TTI(d) REDUCTIONS   */
C214:  PS214B=0; PV214B=0;
  IF CY GE 1985 AND MY GE 1986 AND BOD2 IN (1,2,3) AND SEAT2 IN (11,13) THEN DO;
```

NHTSA's evaluation indicates that TTI(d) performance substantially improved in 2-door cars from MY 1985 to 1994, before the FMVSS 214 upgrade took effect, with most of the improvement coming in the last two years. (Substantial additional improvements occurred in both 2- and 4-door cars during and after the phase-in of FMVSS 214, but they have not yet been evaluated.)

```
      IF 1986 LE MY LE 1992 THEN PV214B=.06*(MY-1985);
        ELSE IF MY=1993 THEN PV214B=.68;
        ELSE IF MY GE 1994 THEN PV214B=1; END;
/* LIVES SAVED IN SIDE IMPACTS BY VOLUNTARY TTI(d) REDUCTIONS */
  OLDWTFA=WEIGHTFA;
  IF PS214B GT 0 OR PV214B GT 0 THEN DO;
```

The average TTI(d) improvement in 2-door cars from 1985 to 1994 was associated with a 23 percent reduction of fatality risk for front-seat occupants in side impacts.

```
    IF IMPACT2 IN (2,3,4,8,9,10) THEN E=.23; ELSE E=0;
    P=PS214B+PV214B;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS214B=S*PS214B/P;
    CLV214B=S*PV214B/P;
    WEIGHTFA=OLDWTFA+CLS214B+CLV214B; END;
  ELSE DO; CLS214B=0; CLV214B=0; END;
  CL214B=CLS214B+CLV214B;
  CLS=CLS+CLS214B; CLV=CLV+CLV214B; CL=CL+CL214B;

/* ---------------------------------------------------------------- */
/*  208H AUTOMATIC 2-POINT BELTS                                    */
/*  PEAK INSTALLATION YEAR: 1991                                    */
/* ---------------------------------------------------------------- */

/* IDENTIFIES OCCUPANTS WEARING AUTOMATIC 2-POINT BELTS  */
  PS208H=0; PV208H=0;
```

"REST3 = 7" indicates use of 2-point automatic belts. PS208H includes any installation from MY 1987 onwards, because the phase-in of automatic occupant protection began on September 1, 1986.

```
  IF REST3=7 THEN DO; IF MY LE 1986 THEN PV208H=1; ELSE PS208H=1; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY AUTOMATIC 2-POINT BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208H GT 0 OR PV208H GT 0 THEN DO;
```

Two-point automatic belts reduce fatalities by an estimated 30 percent in frontals, 18 percent in side impacts, 62 percent in rollovers and 68 percent in rear/other impacts. In general, 21 percent of unrestrained front-outboard occupant fatalities in frontal crashes were ejected, 23 percent in side impacts, 66 percent in rollovers and 35 percent in rear/other impacts.

```
    IF CRSH=1 THEN DO; E=.30; EJECT2=.21; END;
      ELSE IF CRSH=2 THEN DO; E=.18; EJECT2=.23; END;
      ELSE IF CRSH=3 THEN DO; E=.62; EJECT2=.66; END;
      ELSE IF CRSH=4 THEN DO; E=.68; EJECT2=.35; END;
    P=PS208H+PV208H;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208H=S*PS208H/P;
    CLV208H=S*PV208H/P;
    WEIGHTFA=OLDWTFA+CLS208H+CLV208H; END;
  ELSE DO; CLS208H=0; CLV208H=0; END;
  CL208H=CLS208H+CLV208H;
  CLS=CLS+CLS208H; CLV=CLV+CLV208H; CL=CL+CL208H;
```

```
/* ---------------------------------------------------------------- */
/*  208G 3-POINT BELTS FOR BACK-SEAT OUTBOARD OCCUPANTS             */
/*  MEDIAN INSTALLATION YEAR: 1989                                  */
/* ---------------------------------------------------------------- */

/* IDENTIFIES BACK-SEAT OCCUPANTS WEARING 3-POINT BELTS  */
  PS208G=0; PV208G=0;
  IF SEAT2=21 AND REST3=3 THEN DO; IF MY LE 1989 THEN PV208G=1; ELSE PS208G=1; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY BACK-SEAT 3-POINT BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208G GT 0 OR PV208G GT 0 THEN DO;
```

Three-point belts in the rear-outboard seats reduce fatalities by 29 percent in frontals, 42 percent in side impacts, 77 percent in rollovers and 31 percent in rear/other impacts. In general, 23 percent of unrestrained rear-outboard occupant fatalities in frontal crashes were ejected, 28 percent in side impacts, 61 percent in rollovers and 27 percent in rear/other impacts.

```
    IF CRSH=1 THEN DO; E=.29; EJECT2=.23; END;
      ELSE IF CRSH=2 THEN DO; E=.42; EJECT2=.28; END;
      ELSE IF CRSH=3 THEN DO; E=.77; EJECT2=.61; END;
      ELSE IF CRSH=4 THEN DO; E=.31; EJECT2=.27; END;
    P=PS208G+PV208G;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208G=S*PS208G/P;
    CLV208G=S*PV208G/P;
    WEIGHTFA=OLDWTFA+CLS208G+CLV208G; END;
  ELSE DO; CLS208G=0; CLV208G=0; END;
  CL208G=CLS208G+CLV208G;
  CLS=CLS+CLS208G; CLV=CLV+CLV208G; CL=CL+CL208G;

/* ---------------------------------------------------------------- */
/*  213 CHILD SAFETY SEATS                                          */
/*  USE RATE WENT OVER 50% IN: 1985                                 */
/* ---------------------------------------------------------------- */

/* IDENTIFIES CHILD PASSENGERS IN SAFETY SEATS  */
  PS213=0; PV213=0;
  IF REST3=4 THEN DO;
```

"REST3 = 4" indicates a child passenger in a safety seat (not necessarily correctly used). FMVSS 213 regulates the performance of safety seats but does not mandate their use. Therefore, the distinction between PV213 and PS213 will not be based on the effective date of FMVSS 213 (April 1, 1971) but on whether the child was covered by a State law for child passenger protection. That depends on the State and the age of the child. Here are when the State laws took effect, and for what age groups:

```
    IF STATE=47 AND CY GE 1978 AND AGE LE 3 THEN PS213=1;
      ELSE IF STATE=44 AND CY GE 1980 AND AGE LE 5 THEN PS213=1;
      ELSE IF STATE=54 AND CY GE 1981 AND AGE LE 2 THEN PS213=1;
      ELSE IF STATE=25 AND CY GE 1982 AND AGE LE 5 THEN PS213=1;
      ELSE IF STATE IN (9,10,20,21,26,36,37) AND CY GE 1982 AND AGE LE 3 THEN PS213=1;
      ELSE IF STATE IN (32,34,35) AND CY GE 1983 AND AGE LE 4 THEN PS213=1;
      ELSE IF STATE IN (1,6,11,12,17,28,33,39,45,51,55) AND CY GE 1983 AND AGE LE 3 THEN PS213=1;
      ELSE IF STATE=15 AND CY GE 1983 AND AGE LE 2 THEN PS213=1;
      ELSE IF STATE IN (4,5,46,50) AND CY GE 1984 AND AGE LE 4 THEN PS213=1;
      ELSE IF STATE IN (8,18,23,24,27,29,31,40,41,42) AND CY GE 1984 AND AGE LE 3 THEN PS213=1;
      ELSE IF STATE IN (13,38,53) AND CY GE 1984 AND AGE LE 2 THEN PS213=1;
      ELSE IF STATE IN (30,49) AND CY GE 1984 AND AGE LE 1 THEN PS213=1;
      ELSE IF STATE=56 AND CY GE 1985 AND AGE LE 4 THEN PS213=1;
      ELSE IF STATE IN (2,16) AND CY GE 1985 AND AGE LE 3 THEN PS213=1;
      ELSE IF STATE IN (19,22) AND CY GE 1985 AND AGE LE 2 THEN PS213=1;
```

```
      ELSE IF STATE=48 AND CY GE 1985 AND AGE LE 1 THEN PS213=1;
      ELSE PV213=1; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY CHILD SAFETY SEATS */
  OLDWTFA=WEIGHTFA;
  IF PS213 GT 0 OR PV213 GT 0 THEN DO;
```

NHTSA's evaluation estimates that safety seats reduce fatality risk by 71 percent for infants and by 54 percent for toddlers. Effectiveness is not estimated separately by crash mode. In general, 19 percent of unrestrained child passenger fatalities in frontal crashes were ejected, 26 percent in side impacts, 65 percent in rollovers and 34 percent in rear/other impacts.

```
    IF AGE=0 THEN E=.71; ELSE E=.54;
    IF CRSH=1 THEN EJECT2=.19;
      ELSE IF CRSH=2 THEN EJECT2=.26;
      ELSE IF CRSH=3 THEN EJECT2=.65;
      ELSE IF CRSH=4 THEN EJECT2=.34;
    P=PS213+PV213;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS213=S*PS213/P;
    CLV213=S*PV213/P;
    WEIGHTFA=OLDWTFA+CLS213+CLV213; END;
  ELSE DO; CLS213=0; CLV213=0; END;
  CL213=CLS213+CLV213;
  CLS=CLS+CLS213; CLV=CLV+CLV213; CL=CL+CL213;
```

NCAP-related crashworthiness improvement is the only component of the model that is not associated with a specific FMVSS or even a single, specific technology. Nevertheless, cars became safer, saving lives. Starting in 1979, NHTSA's New Car Assessment Program (NCAP) tested the injury performance of belted dummies in 35-mph frontal impacts, and advised the public about the comparative performance of make-models. Starting about 1982, rapidly at first and more gradually in 1984-87, manufacturers modified or redesigned their cars, resulting in substantial improvements on the NCAP test. Modifications included the belt system, the steering assembly, the instrument panel and the seat structure, taking into account how dummies interacted with those systems in 35 mph tests. NHTSA's evaluation showed a 20 percent reduction of fatality risk, for MY 1983-86 vs. MY 1979-82, for belted drivers in head-on collisions with other cars. NHTSA's evaluation did not consider crashes with other types of vehicles or with fixed objects, and it did not study the fatality risk of passengers; the data were limited almost entirely to cars without air bags. We will assume a 20 percent fatality reduction, for belted drivers only (not passengers), when a car frontally impacts another car (but not limited to head-on collisions). Conservatively, we will not assume any benefit for other frontal impacts, such as with an LTV, a heavy truck, or a fixed object; we will limit the benefit to cars without air bags.

```
/* ---------------------------------------------------------------- */
/*  NCAP VOLUNTARY FRONTAL CRASHWORTHINESS IMPROVEMENTS             */
/*  MEDIAN IMPLEMENTATION YEAR: EARLY 1984                          */
/* ---------------------------------------------------------------- */

/* IDENTIFIES NON-AIR-BAG, 3-POINT-BELT CARS WITH IMPROVED NCAP SCORES   */
  PSNCAP=0; PVNCAP=0;
  IF CY GE 1981 AND MY GE 1982 AND PASSIVE IN (0,505) AND SEAT2=11 THEN DO;
      IF MY=1982 THEN PVNCAP=.25;
        ELSE IF MY=1983 THEN PVNCAP=.50;
        ELSE IF MY=1984 THEN PVNCAP=.67;
        ELSE IF MY=1985 THEN PVNCAP=.83;
        ELSE IF MY GE 1986 THEN PVNCAP=1; END;
/* LIVES SAVED BY NCAP-RELATED IMPROVEMENTS: BELTED DRIVERS IN HEAD-ON CRASHES WITH CARS */
  OLDWTFA=WEIGHTFA;
  IF PSNCAP GT 0 OR PVNCAP GT 0 THEN DO;
    IF REST3=3 AND IMPACT2 IN (1,11,12) AND OVTYP=1 THEN E=.20; ELSE E=0;
    P=PSNCAP+PVNCAP;
    S=OLDWTFA*E*P / (1 - E*P);
    CLSNCAP=S*PSNCAP/P;
    CLVNCAP=S*PVNCAP/P;
    WEIGHTFA=OLDWTFA+CLSNCAP+CLVNCAP; END;
  ELSE DO; CLSNCAP=0; CLVNCAP=0; END;
  CLNCAP=CLSNCAP+CLVNCAP;
  CLS=CLS+CLSNCAP; CLV=CLV+CLVNCAP; CL=CL+CLNCAP;

/* ---------------------------------------------------------------- */
/*  208F 3-POINT BELTS FOR FRONT-SEAT OUTBOARD OCCUPANTS            */
/*  MEDIAN INSTALLATION YEAR: 1974                                  */
/* ---------------------------------------------------------------- */

/* IDENTIFIES FRONT-SEAT OCCUPANTS WEARING 3-POINT BELTS  */
  PS208F=0; PV208F=0;
```

"REST3 = 3" includes use of manual 3-point belts, use of automatic 3-point belts, and use of both belts at seats with separate lap and shoulder belts (i.e., for the separate belts only, FARS must say REST_USE = 3; for the 3-point systems, REST_USE can be 1, 2, 3, 8, 13 or imputed). The FMVSS 208 requirement for integral 3-point belts took effect on September 1, 1973 (model year 1974); all lap/shoulder belt use (integral or separate) before MY 1974 will be credited to PV208F.

```
  IF SEAT2 IN (11,13) AND REST3=3 THEN DO; IF MY LE 1973 THEN PV208F=1; ELSE PS208F=1; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY FRONT-OUTBOARD 3-POINT BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208F GT 0 OR PV208F GT 0 THEN DO;
```

With the abundant data for evaluating lap/shoulder belt effectiveness, it is possible to fine-tune the estimates more than for other belt systems: 60 percent fatality reduction in single-vehicle frontals, 42 percent in multivehicle frontals; 21 percent in single-vehicle nearside; 5 percent in multivehicle nearside; 46 percent in single-vehicle farside; 35 percent in multivehicle farside; 74 percent in rollovers; 56 percent in rear/other impacts. The proportion of unrestrained fatalities that were ejectees is also computed separately for each of those crash types.

```
    IF CRSH=1 AND VE_FORMS=1 THEN DO; E=.60; EJECT2=.31; END;
      ELSE IF CRSH=1 THEN DO; E=.42; EJECT2=.12; END;
      ELSE IF CRSH=2 THEN DO;
        IF VE_FORMS=1 AND
          ((SEAT2=11 AND IMPACT2 IN (8,9,10)) OR (SEAT2=13 AND IMPACT2 IN (2,3,4)))
          THEN DO; E=.21; EJECT2=.33; END;
        ELSE IF ((SEAT2=11 AND IMPACT2 IN (8,9,10)) OR (SEAT2=13 AND IMPACT2 IN (2,3,4)))
          THEN DO; E=.05; EJECT2=.15; END;
        ELSE IF VE_FORMS=1 THEN DO; E=.46; EJECT2=.36; END;
```

```
        ELSE DO; E=.35; EJECT2=.20; END; END;
      ELSE IF CRSH=3 THEN DO; E=.74; EJECT2=.66; END;
      ELSE IF CRSH=4 THEN DO; E=.56; EJECT2=.35; END;
    P=PS208F+PV208F;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208F=S*PS208F/P;
    CLV208F=S*PV208F/P;
    WEIGHTFA=OLDWTFA+CLS208F+CLV208F; END;
  ELSE DO; CLS208F=0; CLV208F=0; END;
  CL208F=CLS208F+CLV208F;
  CLS=CLS+CLS208F; CLV=CLV+CLV208F; CL=CL+CL208F;

/* ---------------------------------------------------------------- */
/*  216 B-PILLARS FOR HARDTOP CARS AND OTHER ROOF STRENGTHENING     */
/*  MEDIAN INSTALLATION YEAR: 1973                                  */
/* ---------------------------------------------------------------- */

/* ROOF STRENGTH IMPROVED GRADUALLY FROM 1970 TO 1977      */
  IF MY LE 1969 THEN DO; PS216=0; PV216=0; END;
    ELSE IF 1970 LE MY LE 1973 THEN DO; PS216=0; PV216=.125*(MY-1969); END;
    ELSE IF 1974 LE MY LE 1976 THEN DO; PS216=.125*(MY-1969); PV216=0; END;
    ELSE IF MY GE 1977 THEN DO; PS216=1; PV216=0; END;
/* REDUCTION IN NONEJECTION ROLLOVER FATALITY RISK WITH IMPROVED ROOF STRENGTH */
  OLDWTFA=WEIGHTFA;
```

Roof crush resistance can benefit any non-ejected occupant (EJECT2 NE 1) within the vehicle (SEAT2 NE 52) in a rollover crash. NHTSA's evaluation showed an overall 7.4 percent reduction in non-ejection rollover fatalities during the 1970-77 implementation period associated with FMVSS 216. This is one of the FMVSS where it was important to track the changes in EJECT2 in previous steps of the model. But EJECT2 also has to be recomputed at the end of this step EJECT2 = EJECT2/(1+REL_S), because "removing" roof crush strength increases non-ejection fatalities, and thus increases the proportion of fatalities that are not ejected

```
  IF (PS216 GT 0 OR PV216 GT 0) AND (CRSH=3 OR M_HARM=1)
      AND SEAT2 NE 52 AND EJECT2 NE 1 THEN DO;
    E=.074;
    P=PS216+PV216;
    REL_S=(1-EJECT2)*E*P / (1 - E*P);
    S=OLDWTFA*REL_S;
    CLS216=S*PS216/P;
    CLV216=S*PV216/P;
    WEIGHTFA=OLDWTFA+CLS216+CLV216;
    EJECT2=EJECT2/(1+ REL_S); END;
  ELSE DO; CLS216=0; CLV216=0; END;
  CL216=CLS216+CLV216;
  CLS=CLS+CLS216; CLV=CLV+CLV216; CL=CL+CL216;
```

```
/* ---------------------------------------------------------------- */
/*  214A SIDE DOOR BEAMS                                            */
/*  MEDIAN INSTALLATION YEAR: EARLY 1973                            */
/* ---------------------------------------------------------------- */

/* IDENTIFIES CARS WITH SIDE DOOR BEAMS                    */
```

We know exactly when each make-model was equipped with side door beams. PS214A and PV214A can be set to 0 or 1 (or possibly to .5 in MY 1973 because FMVSS 214 took effect in the middle of the model year). Identification of make-models is based on the VIN, if available, and on the FARS MAK_MOD code, otherwise.

```
  IF MY GE 1974 THEN DO; PS214A=1; PV214A=0; GOTO SAVE214; END;
  IF MY LE 1968 THEN DO; PS214A=0; PV214A=0; GOTO SAVE214; END;
  IF 1969 LE MY LE 1972 THEN PS214A=0;
    ELSE IF MY=1973 THEN PS214A=.5;
  IF MAKE IN (1,7,9,12,13,14,18,19,20,21,22) THEN GOTO SOMEVOL;
    ELSE GOTO NOVOL;
SOMEVOL: V13=V1||V2||V3;
  IF V13 IN ('999','000','   ') THEN GOTO NOVIN;
  IF MY=1969 THEN DO;
    IF MAKE IN (1,7,9,12,13,14) THEN PV214A=0;
      ELSE IF MAKE IN (18,20,21,22) AND V2 IN ('5','6','7','8') THEN PV214A=1;
      ELSE IF MAKE=19 AND V1 NE 'H' THEN PV214A=1;
      ELSE PV214A=0; GOTO SAVE214; END;
  IF MY=1970 THEN DO;
    IF MAKE IN (1,12,13,14) THEN PV214A=0;
      ELSE IF MAKE IN (18,20,21,22) AND V2 IN ('3','4','5','6','7','8') THEN PV214A=1;
      ELSE IF MAKE=19 AND V1 NE 'H' THEN PV214A=1;
      ELSE IF MAKE IN (20,22) AND V2='2' THEN PV214A=.5;
      ELSE IF MAKE=7 AND V1='J' THEN PV214A=1;
      ELSE IF MAKE=9 AND V1='B' THEN PV214A=1;
      ELSE PV214A=0; GOTO SAVE214; END;
  IF MY=1971 THEN DO;
    IF MAKE IN (18,19,21,22) THEN PV214A=1;
      ELSE IF MAKE=20 AND V2 IN ('2','3','4','5','6') THEN PV214A=1;
      ELSE IF MAKE=12 AND V3 IN ('0','5','6','7') THEN PV214A=1;
      ELSE IF MAKE=13 AND V4 IN ('1','2') THEN PV214A=1;
      ELSE IF MAKE=14 AND V3 IN ('4','5','6','7','9') THEN PV214A=1;
      ELSE IF MAKE=7 AND V1='J' THEN PV214A=1;
      ELSE IF MAKE=9 AND V1='B' THEN PV214A=1;
      ELSE IF MAKE=1 AND V4 IN ('3','7') THEN PV214A=1;
      ELSE PV214A=0; GOTO SAVE214; END;
  IF MY=1972 THEN DO;
    IF MAKE IN (13,18,19,21) THEN PV214A=1;
      ELSE IF MAKE=20 AND V2 NE 'X' AND V2 NE 'Z' THEN PV214A=1;
      ELSE IF MAKE=22 AND V2 NE 'Y' THEN PV214A=1;
      ELSE IF MAKE=12 AND V3 IN ('0','2','3','4','5','6','7') THEN PV214A=1;
      ELSE IF MAKE=14 AND V3 NE '3' THEN PV214A=1;
      ELSE IF MAKE=7 AND V1='J' THEN PV214A=1;
      ELSE IF MAKE=9 AND V1='B' THEN PV214A=1;
      ELSE IF MAKE=1 AND V4='7' THEN PV214A=1;
      ELSE PV214A=0; GOTO SAVE214; END;
  IF MY=1973 THEN DO;
    IF MAKE IN (1,13,14,18,19,20,21,22) THEN PV214A=.5;
      ELSE IF MAKE=12 AND V3 NE '8' THEN PV214A=.5;
      ELSE IF MAKE=7 AND V1='J' THEN PV214A=.5;
      ELSE IF MAKE=9 AND V1='B' THEN PV214A=.5;
      ELSE PV214A=0; GOTO SAVE214; END;
NOVIN: IF MY=1969 THEN DO;
    IF MAKE IN (1,7,9,12,13,14) THEN PV214A=0;
      ELSE IF MAK_MOD IN (1802,18002,1803,18003,1903,19003,2002,20002,
                          2102,21002,2103,21003,2202,22002,2210,22010) THEN PV214A=1;
      ELSE PV214A=0; GOTO SAVE214; END;
```

```
  IF MY=1970 THEN DO;
    IF MAKE IN (1,12,13,14) THEN PV214A=0;
      ELSE IF MAK_MOD IN (1802,18002,1803,18003,1903,19003,2002,20002,
                          2102,21002,2103,21003,2202,22002,2210,22010,
                          1801,18001,2001,20001,2101,21001,2201,22001,
                          2010,20010,705,7005,905,9005) THEN PV214A=1;
      ELSE IF MAK_MOD IN (2009,20009,2209,22009) THEN PV214A=.5;
      ELSE PV214A=0; GOTO SAVE214; END;
  IF MY=1971 THEN DO;
    IF MAKE IN (18,19,21,22) THEN PV214A=1;
      ELSE IF MAK_MOD IN (2002,20002,2001,20001,2010,20010,705,7005,905,9005,
                          2009,20009,2011,20011,
                          1203,12003,1206,12006,1301,13001,1404,14004,1406,14006,
                          105,1005,106,1006) THEN PV214A=1;
      ELSE PV214A=0; GOTO SAVE214; END;
  IF MY=1972 THEN DO;
    IF MAKE IN (13,18,19,21) THEN PV214A=1;
      ELSE IF MAK_MOD IN (2002,20002,2001,20001,2010,20010,705,7005,905,9005,
                          2009,20009,2011,20011,
                          1203,12003,1206,12006,1202,12002,1404,14004,1406,14006,
                          1402,14002,105,1005,106,1006) THEN PV214A=1;
      ELSE IF MAKE=22 AND MAK_MOD NE 2208 AND MAK_MOD NE 22008 THEN PV214A=1;
      ELSE PV214A=0; GOTO SAVE214; END;
  IF MY=1973 THEN DO;
    IF MAKE IN (1,13,14,18,19,20,21,22) THEN PV214A=.5;
      ELSE IF MAKE=12 AND MAK_MOD NE 1204 AND MAK_MOD NE 12004 THEN PV214A=.5;
      ELSE IF MAK_MOD IN (705,7005,905,9005) THEN PV214A=.5;
      ELSE PV214A=0; GOTO SAVE214; END;
NOVOL: IF 1969 LE MY LE 1972 THEN DO; PS214A=0; PV214A=0; GOTO SAVE214; END;
   ELSE IF MY=1973 THEN DO; PS214A=.5; PV214A=0; GOTO SAVE214; END;
/* REDUCTION IN SINGLE-VEHICLE SIDE-IMPACT FATALITIES WITH SIDE DOOR BEAMS     */
SAVE214:  OLDWTFA=WEIGHTFA;
```

Side door beams reduce fatality risk by 14 percent for front- and rear-outboard occupants in single-vehicle crashes. Whenever possible (CY GE 1979), also exclude collisions with parked vehicles from the "single" vehicle crashes.

```
  IF (PS214A GT 0 OR PV214A GT 0) AND IMPACT2 IN (2,3,4,8,9,10) AND
      SEAT2 IN (11,13,21) AND
      (VE_FORMS=1 OR (CY GE 1979 AND M_HARM NE 12 AND M_HARM NE 13 AND M_HARM NE 14))
      THEN DO;
    E=.14;
    P=PS214A+PV214A;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS214A=S*PS214A/P;
    CLV214A=S*PV214A/P;
    WEIGHTFA=OLDWTFA+CLS214A+CLV214A; END;
  ELSE DO; CLS214A=0; CLV214A=0; END;
  CL214A=CLS214A+CLV214A;
  CLS=CLS+CLS214A; CLV=CLV+CLV214A; CL=CL+CL214A;

/* ---------------------------------------------------------------- */
/*  105B FRONT DISC BRAKES                                          */
/*  MEDIAN INSTALLATION YEAR: 1971 (INSTALLATION COMPLETED 1977)    */
/* ---------------------------------------------------------------- */
```

As discussed in the analysis of non-occupant fatalities, front disc brakes were gradually introduced into passenger cars during 1965-77 and they reduce fatal crash involvements of all types by an estimated 0.17 percent.

```
/* IMPLEMENTATION OF FRONT DISC BRAKES */
  IF MY GE 1977 THEN DO; PS105B=1; PV105B=0; END;
    ELSE IF MY LE 1964 THEN DO; PS105B=0; PV105B=0; END;
```

```
    ELSE IF MY=1965 THEN DO; PS105B=0; PV105B=.02; END;
    ELSE IF MY=1966 THEN DO; PS105B=0; PV105B=.03; END;
    ELSE IF MY=1967 THEN DO; PS105B=0; PV105B=.06; END;
    ELSE IF MY=1968 THEN DO; PS105B=0; PV105B=.13; END;
    ELSE IF MY=1969 THEN DO; PS105B=0; PV105B=.28; END;
    ELSE IF MY=1970 THEN DO; PS105B=0; PV105B=.41; END;
    ELSE IF MY=1971 THEN DO; PS105B=0; PV105B=.63; END;
    ELSE IF MY=1972 THEN DO; PS105B=0; PV105B=.74; END;
    ELSE IF MY=1973 THEN DO; PS105B=0; PV105B=.86; END;
    ELSE IF MY=1974 THEN DO; PS105B=0; PV105B=.84; END;
    ELSE IF MY=1975 THEN DO; PS105B=0; PV105B=.93; END;
    ELSE IF MY=1976 AND CY=1975 THEN DO; PS105B=0; PV105B=.99; END;
    ELSE IF MY=1976 THEN DO; PS105B=.50; PV105B=.49; END;
/* CAR OCCUPANT LIVES SAVED BY FRONT DISC BRAKES */
  OLDWTFA=WEIGHTFA;
  IF PS105B GT 0 OR PV105B GT 0 THEN DO;
    E=.0017;
    P=PS105B+PV105B;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS105B=S*PS105B/P;
    CLV105B=S*PV105B/P;
    WEIGHTFA=OLDWTFA+CLS105B+CLV105B; END;
  ELSE DO; CLS105B=0; CLV105B=0; END;
  CL105B=CLS105B+CLV105B;
  CLS=CLS+CLS105B; CLV=CLV+CLV105B; CL=CL+CL105B;

/* ---------------------------------------------------------------- */
/*  201 VOLUNTARY INSTRUMENT PANEL IMPROVEMENTS (FMVSS-201 INSPIRED)  */
/*  MEDIAN IMPLEMENTATION YEAR: 1968                                 */
/* ---------------------------------------------------------------- */

/* IDENTIFIES CARS WITH VOLUNTARY INSTRUMENT PANEL IMPROVEMENTS   */
  PS201=0; PV201=0;
```

Part 1 of this report describes how manufacturers significantly modified mid and lower instrument panels in the years before/after FMVSS 201 took effect, even though the standard as finally issued only regulated the upper part of the instrument panel. The technology benefits right-front passengers (SEAT2 = 13).

```
  IF MY GE 1967 AND SEAT2=13 THEN DO;
      IF MY GE 1973 THEN PV201=1;
        ELSE IF MY=1967 THEN PV201=.25; ELSE IF MY=1968 THEN PV201=.5;
        ELSE IF MY=1969 THEN PV201=.6;  ELSE IF MY=1970 THEN PV201=.7;
        ELSE IF MY=1971 THEN PV201=.8;  ELSE IF MY=1972 THEN PV201=.9; END;
/* LIVES SAVED IN FRONTAL IMPACTS BY INSTRUMENT PANEL IMPROVEMENTS */
  OLDWTFA=WEIGHTFA;
```

The evaluation indicated a 15.9 percent fatality reduction for unrestrained right-front passengers in frontal impacts. Since 3-point belts, automatic belts and child safety seats have already been "removed" from the vehicle, REST3 NE 2 (i.e., not lap-belted) identifies unrestrained people.

```
  IF PS201 GT 0 OR PV201 GT 0 THEN DO;
    IF CRSH=1 AND REST3 NE 2 THEN E=.159; ELSE E=0;
    P=PS201+PV201;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS201=S*PS201/P;
    CLV201=S*PV201/P;
    WEIGHTFA=OLDWTFA+CLS201+CLV201; END;
  ELSE DO; CLS201=0; CLV201=0; END;
  CL201=CLS201+CLV201;
  CLS=CLS+CLS201; CLV=CLV+CLV201; CL=CL+CL201;
```

```
/* ---------------------------------------------------------------- */
/*  203 ENERGY-ABSORBING AND TELESCOPING STEERING ASSEMBLIES        */
/*  MEDIAN IMPLEMENTATION YEAR: 1967                                */
/* ---------------------------------------------------------------- */

/* IDENTIFIES CARS WITH ENERGY-ABSORBING STEERING ASSEMBLIES     */
  PS203=0; PV203=0;
```

FMVSS 203 and 204 took effect on January 1, 1968, but energy-absorbing steering assemblies had already been installed on AMC, Chrysler and GM cars in MY 1967 and all other cars in MY 1968.

```
  IF MY GE 1967 AND SEAT2=11 THEN DO;
      IF MY GE 1969 THEN PS203=1;
        ELSE IF MY=1968 THEN DO; PS203=.5; PV203=.5; END;
        ELSE IF MY=1967 AND MAKE IN (1,6,7,8,9,18,19,20,21,22) THEN PV203=1;
        ELSE IF MY=1967 THEN PV203=0; END;
/* LIVES SAVED IN FRONTAL IMPACTS BY INSTRUMENT PANEL IMPROVEMENTS */
  OLDWTFA=WEIGHTFA;
  IF PS203 GT 0 OR PV203 GT 0 THEN DO;
```

Energy-absorbing steering assemblies reduce the fatality risk of drivers by 12.1 percent in frontal impacts.

```
    IF IMPACT2 IN (11,12,1) THEN E=.121; ELSE E=0;
    P=PS203+PV203;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS203=S*PS203/P;
    CLV203=S*PV203/P;
    WEIGHTFA=OLDWTFA+CLS203+CLV203; END;
  ELSE DO; CLS203=0; CLV203=0; END;
  CL203=CLS203+CLV203;
  CLS=CLS+CLS203; CLV=CLV+CLV203; CL=CL+CL203;
```

```
/* ---------------------------------------------------------------- */
/*  208E LAP BELTS FOR BACK-SEAT CENTER OCCUPANTS                   */
/*  MEDIAN INSTALLATION YEAR: EARLY 1967                            */
/* ---------------------------------------------------------------- */

/* IDENTIFIES BACK-CENTER-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208E=0; PV208E=0;
  IF SEAT2=22 AND REST3=2 AND (5 LE AGE LE 99 OR AGE=.) THEN DO;
     IF MY GE 1969 THEN PS208E=1;
       ELSE IF MY LE 1967 THEN PV208E=1;
```

Lap belts (as a minimum) were required at all designated seating positions of cars and LTVs effective January 1, 1968, but were already installed in many vehicles well before that date. Since 1/1/1968 is in the middle of the 1968 model year, PV = .5 and PS = .5 for MY 1968 for all of the lap belt technologies in cars and LTVs.

```
       ELSE IF MY=1968 THEN DO; PS208E=.5; PV208E=.5; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY BACK-CENTER-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208E GT 0 OR PV208E GT 0 THEN DO;
```

The data from NHTSA's evaluation shows lap belts for rear-outboard passengers reduce fatality risk by 76 percent in rollovers and 39 percent in side impacts, but have little or no net benefit in frontals, rear impacts or other crashes. The same effectiveness estimates are assumed for the rear-center position.

```
    IF CRSH=1 THEN DO; E=.00; EJECT2=.26; END;
      ELSE IF CRSH=2 THEN DO; E=.39; EJECT2=.33; END;
      ELSE IF CRSH=3 THEN DO; E=.76; EJECT2=.64; END;
      ELSE IF CRSH=4 THEN DO; E=.00; EJECT2=.31; END;
    P=PS208E+PV208E;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208E=S*PS208E/P;
    CLV208E=S*PV208E/P;
    WEIGHTFA=OLDWTFA+CLS208E+CLV208E; END;
  ELSE DO; CLS208E=0; CLV208E=0; END;
  CL208E=CLS208E+CLV208E;
  CLS=CLS+CLS208E; CLV=CLV+CLV208E; CL=CL+CL208E;
```

As stated above, any rear-center passenger who was originally wearing 3-point belts was "transformed" to an unrestrained passenger back in the 208J step, and will have bypassed the 208E step.

```
/* ---------------------------------------------------------------- */
/*  105A DUAL MASTER CYLINDERS                                      */
/*  MEDIAN INSTALLATION YEAR: LATE 1966                             */
/* ---------------------------------------------------------------- */
```

As discussed in the analysis of non-occupant fatalities, dual master cylinders were gradually introduced into passenger cars during 1962-67 and they reduce fatal crash involvements of all types by an estimated 0.7 percent.

```
/* IMPLEMENTATION OF DUAL MASTER CYLINDERS */
  IF MY GE 1969 THEN DO; PS105A=1; PV105A=0; END;
    ELSE IF MY LE 1961 THEN DO; PS105A=0; PV105A=0; END;
    ELSE IF MY IN (1962,1963) THEN DO; PS105A=0; PV105A=.09; END;
    ELSE IF MY IN (1964,1965) THEN DO; PS105A=0; PV105A=.07; END;
    ELSE IF MY=1966 THEN DO; PS105A=0; PV105A=.54; END;
    ELSE IF MY=1967 THEN DO; PS105A=0; PV105A=1; END;
    ELSE IF MY=1968 THEN DO; PS105A=.5; PV105A=.5; END;
/* CAR OCCUPANT LIVES SAVED BY DUAL MASTER CYLINDERS */
```

```
  OLDWTFA=WEIGHTFA;
  IF PS105A GT 0 OR PV105A GT 0 THEN DO;
    E=.007;
    P=PS105A+PV105A;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS105A=S*PS105A/P;
    CLV105A=S*PV105A/P;
    WEIGHTFA=OLDWTFA+CLS105A+CLV105A; END;
  ELSE DO; CLS105A=0; CLV105A=0; END;
  CL105A=CLS105A+CLV105A;
  CLS=CLS+CLS105A; CLV=CLV+CLV105A; CL=CL+CL105A;

/* ------------------------------------------------------------------ */
/*  208D LAP BELTS FOR FRONT-SEAT CENTER OCCUPANTS                    */
/*  MEDIAN INSTALLATION YEAR: 1966                                    */
/* ------------------------------------------------------------------ */
```

A double-pair comparison analysis of lap belt effectiveness for front-outboard occupants, conducted in support of this study, found that lap belts reduce fatality risk by 22 percent in frontals, 43 percent in rollovers, and 21 percent in side impacts, rear impacts and other crashes. The same effectiveness is assumed for front-center occupants. However, the proportion of unrestrained fatalities that were ejected was derived specifically from data on front-center occupants.

```
/* IDENTIFIES FRONT-CENTER-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208D=0; PV208D=0;
  IF SEAT2=12 AND REST3=2 AND (5 LE AGE LE 99 OR AGE=.) THEN DO;
     IF MY GE 1969 THEN PS208D=1;
       ELSE IF MY LE 1967 THEN PV208D=1;
       ELSE IF MY=1968 THEN DO; PS208D=.5; PV208D=.5; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY FRONT-CENTER-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208D GT 0 OR PV208D GT 0 THEN DO;
    IF CRSH=1 THEN DO; E=.22; EJECT2=.20; END;
      ELSE IF CRSH=2 THEN DO; E=.21; EJECT2=.22; END;
      ELSE IF CRSH=3 THEN DO; E=.43; EJECT2=.58; END;
      ELSE IF CRSH=4 THEN DO; E=.21; EJECT2=.25; END;
    P=PS208D+PV208D;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208D=S*PS208D/P;
    CLV208D=S*PV208D/P;
    WEIGHTFA=OLDWTFA+CLS208D+CLV208D; END;
  ELSE DO; CLS208D=0; CLV208D=0; END;
  CL208D=CLS208D+CLV208D;
  CLS=CLS+CLS208D; CLV=CLV+CLV208D; CL=CL+CL208D;
```

```
/* ---------------------------------------------------------------- */
/*  212 ADHESIVE WINDSHIELD BONDING                                 */
/*  MEDIAN INSTALLATION YEAR: EARLY 1966                            */
/* ---------------------------------------------------------------- */
```

We know exactly when each domestic make-model, and some imported make-models were equipped with adhesive windshield bonding. PS212 and PV212 can be set to 0 or 1 (or possibly to .5 in MY 1970 because FMVSS 212 took effect in the middle of the model year). Identification of these make-models is based on the VIN, if available, and on the FARS MAK_MOD code, otherwise. Note that some domestic models continued with rubber gasket installations after 1970 (meeting FMVSS 212, but looser than adhesive bonding); for these models, PS212 = 0 as long as the rubber gaskets continued.

For all other make-models, including most Japanese cars, we will conservatively assume that PS212 = 1 only from 1980, even though there is some evidence from NCSS that the rubber gasket installations of the 1970's were about as tight as adhesive bonding in domestic cars.

```
/* IDENTIFIES CARS WITH ADHESIVE WINDSHIELD BONDING         */
  IF MY GE 1980 THEN DO; PS212=1; PV212=0; GOTO SAVE212; END;
  IF MY LE 1962 THEN DO; PS212=0; PV212=0; GOTO SAVE212; END;
  IF MAKE IN (41,51) THEN DO;
    IF MY GE 1971 THEN DO; PS212=1; PV212=0; END;
      ELSE IF MY=1970 THEN DO; PS212=.5; PV212=.5; END;
      ELSE IF MY LE 1969 THEN DO; PS212=0; PV212=0; END; GOTO SAVE212; END;
  IF 1963 LE MY LE 1969 THEN PS212=0;
    ELSE IF 1971 LE MY LE 1979 THEN PV212=0;
  IF MAKE IN (1,6,7,8,9,12,13,14,18,19,20,21,22,30,32,35,49) THEN GOTO SOMEVOL2;
  PS212=0; PV212=0; GOTO SAVE212;
SOMEVOL2: V13=V1||V2||V3;
  IF V13 IN ('999','000','   ') THEN GOTO NOVIN2;
  IF MY=1963 THEN DO;
    IF MAKE=18 AND V1 IN ('A','B','C','0','1','3') THEN PV212=.5;
      ELSE IF MAKE=18 AND V1='7' THEN PV212=1;
      ELSE IF MAKE=21 AND V3 IN ('0','1') THEN PV212=.5;
      ELSE PV212=0; GOTO SAVE212; END;
  IF MY=1964 THEN DO;
    IF MAKE=18 AND V1 IN ('A','B','C','0','1','3','7') THEN PV212=1;
      ELSE IF MAKE=20 AND V2='5' THEN PV212=1;
      ELSE IF MAKE IN (21,22) AND V2 IN ('0','1','2') THEN PV212=1;
      ELSE PV212=0; GOTO SAVE212; END;
  IF MY=1965 THEN DO;
    IF MAKE IN (18,19,21,22) THEN PV212=1;
      ELSE IF MAKE=20 AND V2 IN ('1','9') THEN PV212=0;
      ELSE IF MAKE=20 THEN PV212=1;
      ELSE IF MAKE=12 AND V3 IN ('5','6','7') THEN PV212=1;
      ELSE IF MAKE=14 AND V3 IN ('4','5','6','7') THEN PV212=1;
      ELSE PV212=0; GOTO SAVE212; END;
  IF MY=1966 THEN DO;
    IF MAKE IN (13,14,18,19,21,22) THEN PV212=1;
      ELSE IF MAKE=20 AND V2 IN ('1','9') THEN PV212=0;
      ELSE IF MAKE=20 THEN PV212=1;
      ELSE IF MAKE=12 AND (V3='8' OR (V3='0' AND V4 IN ('7','8','9'))) THEN PV212=0;
      ELSE IF MAKE=12 THEN PV212=1;
      ELSE PV212=0; GOTO SAVE212; END;
  IF MY=1967 THEN DO;
    IF MAKE IN (13,18,19,21,22) THEN PV212=1;
      ELSE IF MAKE=20 AND V2 IN ('1','9') THEN PV212=0;
      ELSE IF MAKE=20 THEN PV212=1;
      ELSE IF MAKE=12 AND V3='0' THEN PV212=0;
      ELSE IF MAKE=12 THEN PV212=1;
      ELSE IF MAKE=14 AND V3='9' THEN PV212=0;
```

```
    ELSE IF MAKE=14 THEN PV212=1;
    ELSE IF MAKE=1 THEN GOTO NOVIN2;
    ELSE PV212=0; GOTO SAVE212; END;
IF MY=1968 THEN DO;
  IF MAKE IN (13,18,19,20,21,22) THEN PV212=1;
    ELSE IF MAKE=12 AND V3='0' THEN PV212=0;
    ELSE IF MAKE=12 THEN PV212=1;
    ELSE IF MAKE=14 AND V3='9' THEN PV212=0;
    ELSE IF MAKE=14 THEN PV212=1;
    ELSE IF MAKE=1 AND V4='0' THEN PV212=0;
    ELSE IF MAKE=1 THEN PV212=1;
    ELSE PV212=0; GOTO SAVE212; END;
IF MY=1969 THEN DO;
  IF MAKE IN (6,8,12,13,14,18,19,20,21,22) THEN PV212=1;
    ELSE IF MAKE=7 AND V1='D' THEN PV212=1;
    ELSE IF MAKE=9 AND V1='P' THEN PV212=1;
    ELSE IF MAKE=1 AND V4='0' THEN PV212=0;
    ELSE IF MAKE=1 THEN PV212=1;
    ELSE PV212=0; GOTO SAVE212; END;
IF MY=1970 THEN DO;
  IF MAKE IN (1,6,8,13,14,18,19,20,21,22) THEN DO; PV212=.5; PS212=.5; END;
    ELSE IF MAKE=12 AND V3='9' THEN DO; PV212=0; PS212=0; END;
    ELSE IF MAKE=12 THEN DO; PV212=.5; PS212=.5; END;
    ELSE IF MAKE=7 AND V1 IN ('D','J') THEN DO; PV212=.5; PS212=.5; END;
    ELSE IF MAKE=9 AND V1 IN ('B','P') THEN DO; PV212=.5; PS212=.5; END;
    ELSE IF MAKE=30 THEN DO; PV212=0; PS212=.5; END;
    ELSE DO; PV212=0; PS212=0; END; GOTO SAVE212; END;
IF MY IN (1971,1972,1973) THEN DO;
  IF MAKE IN (1,6,8,13,18,19,20,21,22,30) THEN PS212=1;
    ELSE IF MAKE=12 AND V3 IN ('1','9') THEN PS212=0;
    ELSE IF MAKE=12 THEN PS212=1;
    ELSE IF MAKE=14 AND V3='3' THEN PS212=0;
    ELSE IF MAKE=14 THEN PS212=1;
    ELSE IF MAKE=7 AND V1='L' THEN PS212=0;
    ELSE IF MAKE=7 THEN PS212=1;
    ELSE IF MAKE=9 AND V1='V' THEN PS212=0;
    ELSE IF MAKE=9 THEN PS212=1;
    ELSE PS212=0; GOTO SAVE212; END;
IF MY IN (1974,1975,1976) THEN DO;
  IF MAKE IN (1,6,8,13,18,19,20,21,22,30) THEN PS212=1;
    ELSE IF MAKE=12 AND V3 IN ('1','9') THEN PS212=0;
    ELSE IF MAKE=12 THEN PS212=1;
    ELSE IF MAKE=14 AND V3 IN ('2','3') THEN PS212=0;
    ELSE IF MAKE=14 THEN PS212=1;
    ELSE IF MAKE=7 AND V1='L' THEN PS212=0;
    ELSE IF MAKE=7 THEN PS212=1;
    ELSE IF MAKE=9 AND V1='V' THEN PS212=0;
    ELSE IF MAKE=9 THEN PS212=1;
    ELSE IF MAKE=35 THEN GOTO NOVIN2;
    ELSE PS212=0;  GOTO SAVE212; END;
IF MY=1977 THEN DO;
  IF MAKE IN (1,6,7,8,9,13,18,19,20,21,22,30) THEN PS212=1;
    ELSE IF MAKE=12 AND V3 IN ('1','9') THEN PS212=0;
    ELSE IF MAKE=12 THEN PS212=1;
    ELSE IF MAKE=14 AND V3 IN ('2','3') THEN PS212=0;
    ELSE IF MAKE=14 THEN PS212=1;
    ELSE IF MAKE=35 THEN GOTO NOVIN2;
    ELSE PS212=0;  GOTO SAVE212; END;
IF MY=1978 THEN DO;
  IF MAKE IN (1,6,7,8,9,13,18,19,20,21,22,30,32) THEN PS212=1;
    ELSE IF MAKE=12 AND V3='1' THEN PS212=.5;
    ELSE IF MAKE=12 THEN PS212=1;
    ELSE IF MAKE=14 AND V3='2' THEN PS212=.5;
    ELSE IF MAKE=14 THEN PS212=1;
    ELSE IF MAKE=49 AND V2='A' THEN PS212=1;
```

```
      ELSE PS212=0;  GOTO SAVE212; END;
  IF MY=1979 THEN DO;
    IF MAKE IN (1,6,7,8,9,12,13,14,18,19,20,21,22,30,32) THEN PS212=1;
      ELSE IF MAKE=49 AND V2='A' AND V4 NE '6' THEN PS212=1;
      ELSE PS212=0;  GOTO SAVE212; END;
NOVIN2: IF MY=1963 THEN DO;
    IF MAK_MOD IN (1801,18001,2101,21001) THEN PV212=.5;
      ELSE IF MAK_MOD IN (1805,18005) THEN PV212=1;
      ELSE PV212=0; GOTO SAVE212; END;
  IF MY=1964 THEN DO;
    IF MAK_MOD IN (1801,18001,1805,18005,2001,20001,2101,21001,2201,22001) THEN PV212=1;
      ELSE PV212=0; GOTO SAVE212; END;
  IF MY=1965 THEN DO;
    IF MAKE IN (18,19,21,22) THEN PV212=1;
      ELSE IF MAK_MOD IN (2004,20004,2008,20008) THEN PV212=0;
      ELSE IF MAKE=20 THEN PV212=1;
      ELSE IF MAK_MOD IN (1206,12006,1406,14006) THEN PV212=1;
      ELSE PV212=0; GOTO SAVE212; END;
  IF MY=1966 THEN DO;
    IF MAKE IN (13,14,18,19,21,22) THEN PV212=1;
      ELSE IF MAK_MOD IN (2004,20004,2008,20008) THEN PV212=0;
      ELSE IF MAKE=20 THEN PV212=1;
      ELSE IF MAK_MOD IN (1203,12003,1204,12004) THEN PV212=0;
      ELSE IF MAKE=12 THEN PV212=1;
      ELSE PV212=0; GOTO SAVE212; END;
  IF MY=1967 THEN DO;
    IF MAKE IN (13,18,19,21,22) THEN PV212=1;
      ELSE IF MAK_MOD IN (2004,20004,2008,20008) THEN PV212=0;
      ELSE IF MAKE=20 THEN PV212=1;
      ELSE IF MAK_MOD IN (1203,12003,1404,14004) THEN PV212=0;
      ELSE IF MAKE IN (12,14) THEN PV212=1;
      ELSE IF MAK_MOD IN (101,1001) THEN PV212=0;
      ELSE IF MAKE=1 THEN PV212=1;
      ELSE PV212=0; GOTO SAVE212; END;
  IF MY=1968 THEN DO;
    IF MAKE IN (13,18,19,20,21,22) THEN PV212=1;
      ELSE IF MAK_MOD IN (1203,12003,1404,14004) THEN PV212=0;
      ELSE IF MAKE IN (12,14) THEN PV212=1;
      ELSE IF MAK_MOD IN (101,1001) THEN PV212=0;
      ELSE IF MAKE=1 THEN PV212=1;
      ELSE PV212=0; GOTO SAVE212; END;
  IF MY=1969 THEN DO;
    IF MAKE IN (6,8,12,13,14,18,19,20,21,22) THEN PV212=1;
      ELSE IF MAK_MOD IN (703,7003,704,7004,903,9003,904,9004) THEN PV212=1;
      ELSE IF MAK_MOD IN (101,1001) THEN PV212=0;
      ELSE IF MAKE=1 THEN PV212=1;
      ELSE PV212=0; GOTO SAVE212; END;
  IF MY=1970 THEN DO;
    IF MAKE IN (1,6,8,13,14,18,19,20,21,22) THEN DO; PV212=.5; PS212=.5; END;
      ELSE IF MAK_MOD IN (1208,12008) THEN DO; PV212=0; PS212=0; END;
      ELSE IF MAKE=12 THEN DO; PV212=.5; PS212=.5; END;
      ELSE IF MAK_MOD IN (703,7003,704,7004,705,7005,903,9003,904,9004,905,9005)
        THEN DO; PV212=.5; PS212=.5; END;
      ELSE IF MAKE=30 THEN DO; PV212=0; PS212=.5; END;
      ELSE DO; PV212=0; PS212=0; END; GOTO SAVE212; END;
  IF MY IN (1971,1972,1973) THEN DO;
    IF MAKE IN (1,6,8,13,18,19,20,21,22,30) THEN PS212=1;
      ELSE IF MAK_MOD IN (1208,12008,1209,12009,1408,14008) THEN PS212=0;
      ELSE IF MAKE IN (12,14) THEN PS212=1;
      ELSE IF MAK_MOD IN (701,7001,901,9001) THEN PS212=0;
      ELSE IF MAKE IN (7,9) THEN PS212=1;
      ELSE PS212=0; GOTO SAVE212; END;
  IF MY IN (1974,1975,1976) THEN DO;
    IF MAKE IN (1,6,8,13,18,19,20,21,22,30) THEN PS212=1;
      ELSE IF MAK_MOD IN (1208,12008,1209,12009,1408,14008,1409,14009) THEN PS212=0;
```

```
      ELSE IF MAKE IN (12,14) THEN PS212=1;
      ELSE IF MAK_MOD IN (701,7001,901,9001) THEN PS212=0;
      ELSE IF MAKE IN (7,9) THEN PS212=1;
      ELSE IF MAK_MOD IN (3538,35038,35008) THEN PS212=1;
      ELSE PS212=0; GOTO SAVE212; END;
  IF MY=1977 THEN DO;
    IF MAKE IN (1,6,7,8,9,13,18,19,20,21,22,30) THEN PS212=1;
      ELSE IF MAK_MOD IN (1208,12008,1209,12009,1408,14008,1409,14009) THEN PS212=0;
      ELSE IF MAKE IN (12,14) THEN PS212=1;
      ELSE IF MAK_MOD IN (3538,35038,35008) THEN PS212=1;
      ELSE PS212=0; GOTO SAVE212; END;
  IF MY=1978 THEN DO;
    IF MAKE IN (1,6,7,8,9,13,18,19,20,21,22,30,32) THEN PS212=1;
      ELSE IF MAK_MOD IN (1209,12009,1409,14009) THEN PS212=.5;
      ELSE IF MAKE IN (12,14) THEN PS212=1;
      ELSE IF MAK_MOD IN (4933,49033,49003) THEN PS212=1;
      ELSE PS212=0; GOTO SAVE212; END;
  IF MY=1979 THEN DO;
    IF MAKE IN (1,6,7,8,9,12,13,14,18,19,20,21,22,30,32) THEN PS212=1;
      ELSE IF MAK_MOD IN (4933,49033,49003) THEN PS212=1;
      ELSE PS212=0; GOTO SAVE212; END;
/* REDUCTION IN EJECTION FATALITY RISK WITH ADHESIVE WINDSHIELD BONDING */
SAVE212:  OLDWTFA=WEIGHTFA;
```

Adhesive windshield bonding is potentially beneficial for any ejected front-seat occupant [SEAT2 IN (11,12,13,18) AND EJECT2 NE 0]. In frontal impacts and rollovers of cars without adhesive bonding, 22 percent of ejections were through the windshield portal; in side and rear impacts, 5 percent were through the windshield portal.[3] Adhesive bonding saves 15 percent of the deaths of windshield ejectees.[4] Thus, adhesive bonding saves .22 x .15 = 3.3 percent of all ejection fatalities in frontals and rollovers; .05 x .15 = 0.75 percent of all ejection fatalities in side and rear impacts.

```
  IF (PS212 GT 0 OR PV212 GT 0) AND SEAT2 IN (11,12,13,18) AND EJECT2 NE 0 THEN DO;
    IF CRSH IN (1,3) THEN E=.033;
      ELSE IF CRSH IN (2,4) THEN E=.0075;
    P=PS212+PV212;
    REL_S=EJECT2*E*P / (1 - E*P);
    S=OLDWTFA*REL_S;
    CLS212=S*PS212/P;
    CLV212=S*PV212/P;
    WEIGHTFA=OLDWTFA+CLS212+CLV212;
```

Because adhesive bonding reduces ejection fatalities while leaving non-ejected fatalities unchanged, EJECT2 = (EJECT2 + REL_S)/(1 + REL_S) must be recomputed after this step.

```
    EJECT2=(EJECT2 + REL_S)/(1 + REL_S); END;
  ELSE DO; CLS212=0; CLV212=0; END;
  CL212=CLS212+CLV212;
  CLS=CLS+CLS212; CLV=CLV+CLV212; CL=CL+CL212;

/* ---------------------------------------------------------------- */
/*  208C LAP BELTS FOR BACK-SEAT OUTBOARD OCCUPANTS                 */
/*  MEDIAN INSTALLATION YEAR: LATE 1965                             */
/* ---------------------------------------------------------------- */

/* IDENTIFIES BACK-OUTBOARD-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208C=0; PV208C=0;
  IF SEAT2=21 AND REST3=2 AND (5 LE AGE LE 99 OR AGE=.) THEN DO;
     IF MY GE 1969 THEN PS208C=1;
```

[3] Kahane, C.J., *An Evaluation of Windshield Glazing and Installation Methods for Passenger Cars*, NHTSA Technical Report No. DOT HS 806 693, Washington, 1985, p. 167.
[4] *Ibid*., p. xxvii.

```
      ELSE IF MY LE 1967 THEN PV208C=1;
      ELSE IF MY=1968 THEN DO; PS208C=.5; PV208C=.5; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY BACK-OUTBOARD-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208C GT 0 OR PV208C GT 0 THEN DO;
```

The data from NHTSA's evaluation shows lap belts for rear-outboard passengers reduce fatality risk by 76 percent in rollovers and 39 percent in side impacts, but have little or no net benefit in frontals, rear impacts or other crashes. The same effectiveness estimates are assumed for the rear-center position.

```
   IF CRSH=1 THEN DO; E=.00; EJECT2=.23; END;
      ELSE IF CRSH=2 THEN DO; E=.39; EJECT2=.28; END;
      ELSE IF CRSH=3 THEN DO; E=.76; EJECT2=.61; END;
      ELSE IF CRSH=4 THEN DO; E=.00; EJECT2=.27; END;
    P=PS208C+PV208C;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208C=S*PS208C/P;
    CLV208C=S*PV208C/P;
    WEIGHTFA=OLDWTFA+CLS208C+CLV208C; END;
  ELSE DO; CLS208C=0; CLV208C=0; END;
  CL208C=CLS208C+CLV208C;
  CLS=CLS+CLS208C; CLV=CLV+CLV208C; CL=CL+CL208C;
```

```
/* ---------------------------------------------------------------- */
/*  206 DOOR LOCK IMPROVEMENTS                                      */
/*  MEDIAN INSTALLATION YEAR: 1965                                  */
/* ---------------------------------------------------------------- */

/* DOOR LOCKS IMPROVED GRADUALLY FROM 1962 TO 1968       */
  IF MY GE 1969 THEN DO; PS206=1; PV206=0; END;
    ELSE IF MY=1968 THEN DO; PS206=.5; PV206=.5; END;
    ELSE IF 1962 LE MY LE 1967 THEN DO; PS206=0; PV206=(MY-1961)/7; END;
    ELSE IF MY LE 1961 THEN DO; PS206=0; PV206=0; END;
/* REDUCTION IN EJECTION ROLLOVER FATALITY RISK WITH IMPROVED DOOR LOCKS */
  OLDWTFA=WEIGHTFA;
```

NHTSA's evaluation found that improved door locks would save 15.38 percent (400 of 2,600 in the baseline year for that study) of ejection fatalities (excluding occupants riding outside the passenger compartment).[5]

```
  IF (PS206 GT 0 OR PV206 GT 0) AND (CRSH=3 OR M_HARM=1)
      AND SEAT2 NE 52 AND EJECT2 NE 0 THEN DO;
    E=.1538;
    P=PS206+PV206;
    REL_S=EJECT2*E*P / (1 - E*P);
    S=OLDWTFA*REL_S;
    CLS206=S*PS206/P;
    CLV206=S*PV206/P;
    WEIGHTFA=OLDWTFA+CLS206+CLV206;
    EJECT2=(EJECT2 + REL_S)/(1 + REL_S); END;
  ELSE DO; CLS206=0; CLV206=0; END;
  CL206=CLS206+CLV206;
  CLS=CLS+CLS206; CLV=CLV+CLV206; CL=CL+CL206;

/* ---------------------------------------------------------------- */
/*  208B LAP BELT USE BY CHILDREN AGE 1-4                           */
/*  MEDIAN INSTALLATION YEAR FOR LAP BELTS USED BY CHILDREN: 1964   */
/* ---------------------------------------------------------------- */

/* IDENTIFIES CHILD PASSENGERS AGE 1-4 USING LAP BELTS */
  PS208B=0; PV208B=0;
  IF 1 LE AGE LE 4 AND REST3=2 THEN DO;
     IF MY GE 1969 THEN PS208B=1;
       ELSE IF MY LE 1967 THEN PV208B=1;
       ELSE IF MY=1968 THEN DO; PS208B=.5; PV208B=.5; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY LAP BELTS (AGE 1-4) */
  OLDWTFA=WEIGHTFA;
  IF PS208B GT 0 OR PV208B GT 0 THEN DO;
```

NHTSA's evaluation estimates that lap belts reduce fatality risk by 33 percent for toddlers. Effectiveness is not estimated separately by crash mode.[6] In general, 19 percent of unrestrained child passenger fatalities in frontal crashes were ejected, 26 percent in side impacts, 65 percent in rollovers and 34 percent in rear/other impacts.

```
    E=.33;
    IF CRSH=1 THEN EJECT2=.19;
      ELSE IF CRSH=2 THEN EJECT2=.26;
```

[5] Kahane, C.J., *An Evaluation of Door Locks and Roof Crush Resistance of Passenger Cars – Federal Motor Vehicle Safety Standards 206 and 216*, NHTSA Technical Report No. DOT HS 807 489, Washington, 1989, pp. 206-209 and 222-225.

[6] This evaluation is discussed in the "Child Safety Seats" section of the FMVSS 213 chapter of Part 1, not the FMVSS 208 chapter.

```
      ELSE IF CRSH=3 THEN EJECT2=.65;
      ELSE IF CRSH=4 THEN EJECT2=.34;
    P=PS208B+PV208B;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208B=S*PS208B/P;
    CLV208B=S*PV208B/P;
    WEIGHTFA=OLDWTFA+CLS208B+CLV208B; END;
  ELSE DO; CLS208B=0; CLV208B=0; END;
  CL208B=CLS208B+CLV208B;
  CLS=CLS+CLS208B; CLV=CLV+CLV208B; CL=CL+CL208B;

/* ------------------------------------------------------------------ */
/*  208A LAP BELTS FOR FRONT-SEAT OUTBOARD OCCUPANTS                  */
/*  MEDIAN INSTALLATION YEAR: 1962                                    */
/* ------------------------------------------------------------------ */
```

A double-pair comparison analysis of lap belt effectiveness for front-outboard occupants, conducted in support of this study, found that lap belts reduce fatality risk by 22 percent in frontals, 43 percent in rollovers, and 21 percent in side impacts, rear impacts and other crashes.

```
/* IDENTIFIES FRONT-OUTBOARD-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208A=0; PV208A=0;
  IF SEAT2 IN (11,13) AND REST3=2 AND (5 LE AGE LE 99 OR AGE=.) THEN DO;
     IF MY GE 1969 THEN PS208A=1;
       ELSE IF MY LE 1967 THEN PV208A=1;
       ELSE IF MY=1968 THEN DO; PS208A=.5; PV208A=.5; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY FRONT-OUTBOARD-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208A GT 0 OR PV208A GT 0 THEN DO;
    IF CRSH=1 THEN DO; E=.22; EJECT2=.21; END;
      ELSE IF CRSH=2 THEN DO; E=.21; EJECT2=.23; END;
      ELSE IF CRSH=3 THEN DO; E=.43; EJECT2=.66; END;
      ELSE IF CRSH=4 THEN DO; E=.21; EJECT2=.35; END;
    P=PS208A+PV208A;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208A=S*PS208A/P;
    CLV208A=S*PV208A/P;
    WEIGHTFA=OLDWTFA+CLS208A+CLV208A; END;
  ELSE DO; CLS208A=0; CLV208A=0; END;
  CL208A=CLS208A+CLV208A;
  CLS=CLS+CLS208A; CLV=CLV+CLV208A; CL=CL+CL208A;
  DROP V13;
RUN;
```

That concludes the model for passenger cars. It has estimated, on a case-by-case basis, by how much fatalities would increase if all the safety technologies were "removed" from vehicles. The next step is to tally up the lives saved over all the cases, by calendar year.

```
PROC MEANS SUM NOPRINT DATA=CAR2; BY CY;
  VAR ORIGWT WEIGHTFA
    CLV208J CLS208J CL208J
    CLV108 CLS108 CL108
    CLV208I CLS208I CL208I
    CLV214B CLS214B CL214B
    CLV208H CLS208H CL208H
    CLV208G CLS208G CL208G
    CLV213 CLS213 CL213
    CLVNCAP CLSNCAP CLNCAP
    CLV208F CLS208F CL208F
    CLV216 CLS216 CL216
    CLV214A CLS214A CL214A
    CLV105B CLS105B CL105B
    CLV201 CLS201 CL201
    CLV203 CLS203 CL203
    CLV208E CLS208E CL208E
    CLV105A CLS105A CL105A
    CLV208D CLS208D CL208D
    CLV212 CLS212 CL212
    CLV208C CLS208C CL208C
    CLV206 CLS206 CL206
    CLV208B CLS208B CL208B
    CLV208A CLS208A CL208A
    CABDRV CABRF CABKID
    CLV CLS CL;
  OUTPUT OUT=CAR3
```

C_ORIGWT = actual car occupant fatalities. C_WTFA = estimated number of fatalities if all safety technologies had been removed.

```
    SUM=C_ORIGWT C_WTFA
    CLV208J CLS208J CL208J
    CLV108 CLS108 CL108
    CLV208I CLS208I CL208I
    CLV214B CLS214B CL214B
    CLV208H CLS208H CL208H
    CLV208G CLS208G CL208G
    CLV213 CLS213 CL213
    CLVNCAP CLSNCAP CLNCAP
    CLV208F CLS208F CL208F
    CLV216 CLS216 CL216
    CLV214A CLS214A CL214A
    CLV105B CLS105B CL105B
    CLV201 CLS201 CL201
    CLV203 CLS203 CL203
    CLV208E CLS208E CL208E
    CLV105A CLS105A CL105A
    CLV208D CLS208D CL208D
    CLV212 CLS212 CL212
    CLV208C CLS208C CL208C
    CLV206 CLS206 CL206
    CLV208B CLS208B CL208B
    CLV208A CLS208A CL208A
    CABDRV CABRF CABKID
    CLV CLS CL;
```

Prints the number of lives saved by each technology in each calendar year, and the sum of lives saved in 1975-2002.

```
PROC PRINT DATA=CAR3;
  FORMAT CLV208J CLS208J CL208J CLV108 CLS108 CL108 CLV208I CLS208I CL208I 9.0;
  ID CY; VAR CLV208J CLS208J CL208J CLV108 CLS108 CL108 CLV208I CLS208I CL208I;
  SUM CLV208J CLS208J CL208J CLV108 CLS108 CL108 CLV208I CLS208I CL208I;
```

```
TITLE1 'CAR OCCUPANT LIVES SAVED BY BACK-CENTER 3-POINT BELTS, TRAILER CONSPICUITY TAPE, AND AIR
BAGS, 1975-2002';
TITLE2 ' ';
TITLE3 '...208J = 3-POINT BELTS FOR BACK-CENTER OCCUPANTS (MEDIAN INSTALLATION YEAR 2001, FMVSS
PHASE-IN TO BEGIN 9/2005)';
TITLE4 '...108  = TRAILER CONSPICUITY TAPE (ON-ROAD FLEET 50% EQUIPPED 1996, FMVSS 12/1/93,
RETROFIT 6/1/2001)';
TITLE5 '...208I = FRONTAL AIR BAGS (MEDIAN INSTALLATION YEAR 1994, FMVSS PHASE-IN BEGAN 9/1/86)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=CAR3;
  FORMAT CLV214B CL214B CLV208H CLS208H CL208H CLV208G CLS208G CL208G 9.0;
  ID CY; VAR CLV214B CL214B CLV208H CLS208H CL208H CLV208G CLS208G CL208G;
  SUM CLV214B CL214B CLV208H CLS208H CL208H CLV208G CLS208G CL208G;
TITLE1 'CAR OCCUPANT LIVES SAVED BY VOLUNTARY TTI(d) REDUCTIONS, AUTOMATIC 2-POINT BELTS, AND BACK-
OUTBOARD 3-POINT BELTS, 1975-2002';
TITLE2 ' ';
TITLE3 '...214B = VOLUNTARY TTI(d) REDUCTIONS IN 2-DOOR CARS (MEDIAN IMPLEMENTATION YEAR 1993)';
TITLE4 '...208H = AUTOMATIC 2-POINT BELTS (PEAK INSTALLATION YEAR 1991, FMVSS PHASE-IN BEGAN
9/1/86)';
TITLE5 '...208G = 3-POINT BELTS FOR BACK-OUTBOARD OCCUPANTS (MEDIAN INSTALLATION YEAR 1989, FMVSS
EFFECTIVE 12/11/89)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=CAR3;
  FORMAT CLV213 CLS213 CL213 CLVNCAP CLSNCAP CLNCAP CLV208F CLS208F CL208F 9.0;
  ID CY; VAR CLV213 CLS213 CL213 CLVNCAP CLNCAP CLV208F CLS208F CL208F;
  SUM CLV213 CLS213 CL213 CLVNCAP CLNCAP CLV208F CLS208F CL208F;
TITLE1 'CAR OCCUPANT LIVES SAVED BY CHILD SAFETY SEATS, VOLUNTARY NCAP IMPROVEMENTS, AND FRONT-SEAT
3-POINT BELTS, 1975-2002';
TITLE2 ' ';
TITLE3 '...213  = CHILD SAFETY SEATS (USE EXCEEDED 50% IN 1985, FMVSS EFFECTIVE 4/1/71, STATE LAWS
1978-85)';
TITLE4 '...NCAP = VOLUNTARY NCAP IMPROVEMENTS IN NON-AIR-BAG CARS (MEDIAN IMPLEMENTATION YEAR EARLY
1984)';
TITLE5 '...208F = 3-POINT BELTS FOR FRONT-SEAT OCCUPANTS (MEDIAN INSTALLATION YEAR 1974, FMVSS
EFFECTIVE 9/1/73)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=CAR3;
  FORMAT CLV216 CLS216 CL216 CLV214A CLS214A CL214A CLV105B CLS105B CL105B 9.0;
  ID CY; VAR CLV216 CLS216 CL216 CLV214A CLS214A CL214A CLV105B CLS105B CL105B;
  SUM CLV216 CLS216 CL216 CLV214A CLS214A CL214A CLV105B CLS105B CL105B;
TITLE1 'CAR OCCUPANT LIVES SAVED BY ROOF CRUSH STRENGTH, SIDE DOOR BEAMS, AND FRONT DISC BRAKES,
1975-2002';
TITLE2 ' ';
TITLE3 '...216  = ROOF CRUSH STRENGTH, B-PILLARS, ETC. (MEDIAN INSTALLATION YEAR 1973, FMVSS
EFFECTIVE 9/1/73)';
TITLE4 '...214A = SIDE DOOR BEAMS (MEDIAN INSTALLATION YEAR EARLY 1973, FMVSS EFFECTIVE 1/1/73)';
TITLE5 '...105B = FRONT DISC BRAKES (MEDIAN INSTALLATION YEAR 1971, FMVSS EFFECTIVE 1/1/76)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=CAR3;
  FORMAT CLV201 CL201 CLV203 CLS203 CL203 CLV208E CLS208E CL208E 9.0;
  ID CY; VAR CLV201 CL201 CLV203 CLS203 CL203 CLV208E CLS208E CL208E;
  SUM CLV201 CL201 CLV203 CLS203 CL203 CLV208E CLS208E CL208E;
TITLE1 'CAR OCCUPANT LIVES SAVED BY SAFER INSTRUMENT PANELS, EA STEERING ASSEMBLIES, AND BACK-
CENTER LAP BELTS, 1975-2002';
TITLE2 ' ';
TITLE3 '...201  = VOLUNTARY INSTRUMENT PANEL IMPROVEMENTS (MEDIAN IMPLEMENTATION YEAR 1968, FMVSS
EFFECTIVE 1/1/68)';
```

```
TITLE4 '...203  = ENERGY-ABSORBING STEERING ASSEMBLIES (MEDIAN IMPLEMENTATION YEAR 1967, FMVSS
EFFECTIVE 1/1/68)';
TITLE5 '...208E = LAP BELTS FOR BACK-CENTER OCCUPANTS (MEDIAN INSTALLATION YEAR EARLY 1967, FMVSS
EFFECTIVE 1/1/68)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=CAR3;
  FORMAT CLV105A CLS105A CL105A CLV208D CLS208D CL208D CLV212 CLS212 CL212 9.0;
  ID CY; VAR CLV105A CLS105A CL105A CLV208D CLS208D CL208D CLV212 CLS212 CL212;
  SUM CLV105A CLS105A CL105A CLV208D CLS208D CL208D CLV212 CLS212 CL212;
TITLE1 'CAR OCCUPANT LIVES SAVED BY DUAL MASTER CYLINDERS, FRONT-CENTER LAP BELTS, AND ADHESIVE
WINDSHIELD BONDING, 1975-2002';
TITLE2 ' ';
TITLE3 '...105A = DUAL MASTER CYLINDERS (MEDIAN INSTALLATION YEAR LATE 1966, FMVSS EFFECTIVE
1/1/68)';
TITLE4 '...208D = LAP BELTS FOR FRONT-CENTER OCCUPANTS (MEDIAN INSTALLATION YEAR 1966, FMVSS
EFFECTIVE 1/1/68)';
TITLE5 '...212  = ADHESIVE WINDSHIELD BONDING (MEDIAN INSTALLATION YEAR EARLY 1966, FMVSS EFFECTIVE
1/1/70)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=CAR3;
  FORMAT CLV208C CLS208C CL208C CLV206 CLS206 CL206 CLV208B CLS208B CL208B 9.0;
  ID CY; VAR CLV208C CLS208C CL208C CLV206 CLS206 CL206 CLV208B CLS208B CL208B;
  SUM CLV208C CLS208C CL208C CLV206 CLS206 CL206 CLV208B CLS208B CL208B;
TITLE1 'CAR OCCUPANT LIVES SAVED BY BACK-OUTBOARD LAP BELTS, IMPROVED DOOR LOCKS, AND LAP BELTS FOR
CHILDREN AGE 1-4, 1975-2002';
TITLE2 ' ';
TITLE3 '...208C = LAP BELTS FOR BACK-OUTBOARD OCCUPANTS (MEDIAN INSTALLATION YEAR LATE 1965, FMVSS
EFFECTIVE 1/1/68)';
TITLE4 '...206  = IMPROVED DOOR LOCKS (MEDIAN INSTALLATION YEAR 1965, FMVSS EFFECTIVE 1/1/68)';
TITLE5 '...208B = LAP BELT USE BY CHILDREN AGE 1-4 (MEDIAN INSTALLATION YEAR 1964, FMVSS EFFECTIVE
1/1/68)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=CAR3;
  FORMAT CLV208A CLS208A CL208A 9.0;
  ID CY; VAR CLV208A CLS208A CL208A;
  SUM CLV208A CLS208A CL208A;
TITLE1 'CAR OCCUPANT LIVES SAVED BY FRONT-OUTBOARD LAP BELTS, 1975-2002';
TITLE2 ' ';
TITLE3 '...208A = LAP BELTS FOR FRONT-OUTBOARD OCCUPANTS (MEDIAN INSTALLATION YEAR 1963, FMVSS
EFFECTIVE 1/1/68)';
TITLE4 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE5 '...S = STANDARD INSTALLATIONS, CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';
```

Summary results for cars. CL = total lives saved. PCT_SAVE = percentage of potential fatalities that were saved by the technologies.

```
DATA CAR4; SET CAR3;
PCT_SAVE=100*CL/C_WTFA;
PROC PRINT DATA=CAR4;
  FORMAT C_ORIGWT C_WTFA CLV CLS CL 9.0 PCT_SAVE 6.2;
  ID CY; VAR C_ORIGWT C_WTFA CLV CLS CL PCT_SAVE;
  SUM C_ORIGWT C_WTFA CLV CLS CL;
TITLE1 'OVERALL CAR OCCUPANT LIVES SAVED BY VEHICLE SAFETY STANDARDS AND TECHNOLOGIES, 1975-2002';
TITLE2 ' ';
TITLE3 'C_ORIGWT = ACTUAL CAR OCCUPANT FATALITIES';
TITLE4 'C_WTFA = FATALITIES THAT WOULD HAVE OCCURRED WITHOUT ANY VEHICLE SAFETY IMPROVEMENTS';
TITLE5 'CLV = OVERALL LIVES SAVED BY VOLUNTARY IMPROVEMENTS, BEFORE FMVSS EFFECTIVE DATE';
TITLE6 'CLS = OVERALL LIVES SAVED IN CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';
```

```
TITLE7 'CL = OVERALL LIVES SAVED BY VEHICLE SAFETY IMPROVEMENTS (CLV + CLS)';
TITLE8 'PCT_SAVE = PERCENT OF WOULD-HAVE-BEEN FATALITIES SAVED BY SAFETY STANDARDS AND
TECHNOLOGIES';
RUN;


/* ---------------------------------------------------------------- */
/* ---------------------------------------------------------------- */
/*  LIVES SAVED BY FMVSS IN LIGHT TRUCKS                            */
/* ---------------------------------------------------------------- */
/* ---------------------------------------------------------------- */
```

The main model for LTVs begins here. The basic approach is the same as for cars, but the implementation dates and effectiveness of the various technologies may be different. In general, the notes on this section will be limited to the spots where LTVs differ from cars.

```
DATA TRK2; SET TRK1;
IF EJECTION IN (1,2) THEN EJECT2=1; ELSE EJECT2=0;

/* ---------------------------------------------------------------- */
/*  208J 3-POINT BELTS FOR BACK-SEAT CENTER OCCUPANTS (ANTON'S LAW)   */
/*  MEDIAN INSTALLATION YEAR: > 2001                                */
/* ---------------------------------------------------------------- */

/* IDENTIFIES BACK-SEAT CENTER OCCUPANTS WEARING 3-POINT BELTS  */
  PS208J=0; PV208J=0;
  IF SEAT2=22 AND REST3=3 THEN DO; IF MY LE 2008 THEN PV208J=1; ELSE PS208J=1; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY BACK-SEAT CENTER 3-POINT BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208J GT 0 OR PV208J GT 0 THEN DO;
```

In general, belts are more effective in LTVs than in cars; also, a higher percentage of unrestrained fatalities were ejected. The data in NHTSA's evaluation of 3-point belts in the rear-outboard seats indicate fatality reduction of 50 percent in frontals, 84 percent in rollovers and 70 percent in side, rear and other impacts. We will assume the same effectiveness for 3-point belts in the rear-center seat. In frontal crashes, 49 percent of unrestrained rear-center occupant fatalities were ejected, 59 percent in side impacts, 85 percent in rollovers and 58 percent in rear/other impacts.

TLV208J: "T" = car, "L" = lives saved, "V" = voluntary, "208J" = rear-center 3-point belt

```
    IF CRSH=1 THEN DO; E=.50; EJECT2=.49; END;
      ELSE IF CRSH=2 THEN DO; E=.70; EJECT2=.59; END;
      ELSE IF CRSH=3 THEN DO; E=.84; EJECT2=.85; END;
      ELSE IF CRSH=4 THEN DO; E=.70; EJECT2=.58; END;
    P=PS208J+PV208J;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208J=S*PS208J/P;
    TLV208J=S*PV208J/P;
    WEIGHTFA=OLDWTFA+TLS208J+TLV208J; END;
  ELSE DO; TLS208J=0; TLV208J=0; END;
  TL208J=TLS208J+TLV208J;
  TLS=TLS208J; TLV=TLV208J; TL=TL208J;

/* ---------------------------------------------------------------- */
/*  108 TRAILER CONSPICUITY TAPE - LIVES SAVED, LTRKS NOT HITTING THEM  */
/*  50% OF TRAILERS ON THE ROAD HAD THEM IN: 1996                   */
/*  FMCSA RETROFIT REQUIREMENT ISSUED 3/31/1999, TOOK EFFECT 6/1/2001   */
/* ---------------------------------------------------------------- */

/* IDENTIFIES SIDE/REAR IMPACTS INTO TRAILERS IN THE DARK AND % OF TRAILERS WITH TAPE */
  PS108=0; PV108=0;
```

```
  IF CY GE 1991 AND (TAPECASE=1 OR (OVTYP=3 AND
    ((1991 LE CY LE 1994 AND OVCONFIG=5) OR (CY GE 1995 AND OVCONFIG=6))
    AND 2 LE LGT_COND LE 5 AND
      (OIMPACT2 IN (14,16) AND MAN_COLL IN (1,4,5) AND IMPACT2 IN (11,12,1))))
    THEN DO;
      IF CY=1991 THEN DO; PS108=0; PV108=.09; END;
        ELSE IF CY=1992 THEN DO; PS108=0; PV108=.18; END;
        ELSE IF CY=1993 THEN DO; PS108=0; PV108=.27; END;
        ELSE IF CY=1994 THEN DO; PS108=.09; PV108=.27; END;
        ELSE IF CY=1995 THEN DO; PS108=.18; PV108=.27; END;
        ELSE IF CY=1996 THEN DO; PS108=.27; PV108=.27; END;
        ELSE IF CY=1997 THEN DO; PS108=.36; PV108=.27; END;
        ELSE IF CY=1998 THEN DO; PS108=.45; PV108=.27; END;
        ELSE IF CY=1999 THEN DO; PS108=.54; PV108=.27; END;
        ELSE IF CY=2000 THEN DO; PS108=.63; PV108=.27; END;
        ELSE IF CY=2001 THEN DO; PS108=.8775; PV108=.1125; END;
        ELSE IF CY GE 2002 THEN DO; PS108=1; PV108=0; END; END;
/* LIGHT TRUCK OCCUPANT LIVES SAVED BY CONSPICUITY TAPE ON TRUCK TRAILERS */
  OLDWTFA=WEIGHTFA;
  IF PS108 GT 0 OR PV108 GT 0 THEN DO;
    E=.29;
    P=PS108+PV108;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS108=S*PS108/P;
    TLV108=S*PV108/P;
    WEIGHTFA=OLDWTFA+TLS108+TLV108; END;
  ELSE DO; TLS108=0; TLV108=0; END;
  TL108=TLS108+TLV108;
  TLS=TLS+TLS108; TLV=TLV+TLV108; TL=TL+TL108;

/* ---------------------------------------------------------------- */
/*  208I FRONTAL AIR BAGS FOR DRIVERS AND RF PASSENGERS AGE 13+     */
/*  ASSUMES 18 PERCENT OF ON-OFF SWITCHES ARE TURNED OFF FOR RF 13+ */
/*  MEDIAN INSTALLATION YEAR: 1995                                  */
/* ---------------------------------------------------------------- */

/* IDENTIFIES LIGHT TRUCKS WITH AIR BAGS  */
  PS208I=0; PV208I=0; UDAB=0; UPAB=0;
```

"PASSIVE," the variable that indicates the types of occupant protection at the front-outboard seats, is only defined if FARS has at least a partial VIN to decode. However, even when there is no VIN at all, we can often infer from the body type, the model year and the make if the LTV had driver and/or passenger air bags. All SUVs and minivans from MY 1998 onwards have had dual air bags; all compact pickups have had driver air bags from MY 1998 onwards. Some makes had driver air bags (UDAB = 1) or passenger air bags (UPAB = 1) on all LTVs of a certain body type before 1998. Because the FARS body types "large van" and "standard pickup" include vehicles with GVWR over 8,500 pounds, they may be without air bags even after 1998.

```
/* LTVs WITH UNKNOWN "PASSIVE" (BAD VINs) CLASSIFIED BY MAKE, BODY_TYP AND MODEL YEAR */

  IF CY GE 1991 AND MY GE 1992 AND (PASSIVE=. OR PASSIVE=9999) AND SEAT2 IN (11,13) THEN DO;
    IF SEAT2=11 THEN DO;
      IF (MAKE IN (6,9) AND MY GE 1992)
      OR (MAKE IN (7,12,49) AND BODY_TYP=20 AND MY GE 1992)
      OR (MAKE=41 AND BODY_TYP=20 AND MY GE 1993)
      OR (MAKE IN (14,21,22) AND MY GE 1994)
      OR (MAKE=7 AND BODY_TYP=30 AND MY GE 1994)
      OR (MAKE=12 AND BODY_TYP IN (15,16) AND MY GE 1994)
      OR (MAKE IN (20,23,35) AND BODY_TYP=20 AND MY GE 1994)
      OR (MAKE=49 AND BODY_TYP=31 AND MY GE 1994)
      OR (MAKE=30 AND MY GE 1995)
      OR (MAKE=7 AND BODY_TYP=21 AND MY GE 1995)
```

```
      OR (MAKE IN (12,20,23) AND BODY_TYP=30 AND MY GE 1995)
      OR (MAKE IN (12,23) AND BODY_TYP=14 AND MY GE 1995)
      OR (MAKE IN (20,23,49) AND BODY_TYP IN (15,16) AND MY GE 1995)
      OR (MAKE=12 AND BODY_TYP=21 AND MY GE 1995)
      OR (MAKE IN (2,37,53,54,59,62) AND MY GE 1996)
      OR (MAKE IN (20,38,49) AND BODY_TYP=14 AND MY GE 1996)
      OR (MAKE IN (35,38,41,49) AND BODY_TYP=30 AND MY GE 1996)
      OR (MAKE=38 AND BODY_TYP=20 AND MY GE 1996)
      OR (MAKE IN (52,58,63) AND MY GE 1997)
      OR (MAKE=35 AND BODY_TYP=14 AND MY GE 1997)
      OR (MAKE IN (13,18,19,34,42,48,55) AND MY GE 1998)
      OR (MAKE=7 AND BODY_TYP IN (15,16) AND MY GE 1998)
      OR (MAKE=41 AND BODY_TYP=14 AND MY GE 1998)
      OR (MAKE=12 AND BODY_TYP=31 AND MY GE 1999)
      OR (MAKE IN (20,23) AND BODY_TYP=31 AND MY GE 2001)
   THEN UDAB=1; END;

    ELSE IF SEAT2=13 THEN DO;
      IF (MAKE IN (6,9) AND MY GE 1994)
      OR (MAKE IN (7,49) AND BODY_TYP=20 AND MY GE 1994)
      OR (MAKE=12 AND BODY_TYP=14 AND MY GE 1995)
      OR (MAKE=49 AND BODY_TYP IN (15,16) AND MY GE 1995)
      OR (MAKE IN (14,37,53,54,59,62) AND MY GE 1996)
      OR (MAKE IN (23,35,38,41) AND BODY_TYP=20 AND MY GE 1996)
      OR (MAKE IN (38,49) AND BODY_TYP=14 AND MY GE 1996)
      OR (MAKE IN (2,22,30,52,58) AND MY GE 1997)
      OR (MAKE IN (12,20,23) AND BODY_TYP IN (15,16) AND MY GE 1997)
      OR (MAKE=12 AND BODY_TYP=21 AND MY GE 1997)
      OR (MAKE=20 AND BODY_TYP=20 AND MY GE 1997)
      OR (MAKE=35 AND BODY_TYP=14 AND MY GE 1997)
      OR (MAKE IN (13,18,19,21,34,42,48,55,63) AND MY GE 1998)
      OR (MAKE=7 AND BODY_TYP IN (15,16) AND MY GE 1998)
      OR (MAKE=7 AND BODY_TYP=21 AND MY GE 1998)
      OR (MAKE=12 AND BODY_TYP=20 AND MY GE 1998)
      OR (MAKE IN (20,23,41) AND BODY_TYP=14 AND MY GE 1998)
    THEN UPAB=1; END; END;
```

These are the codes of PASSIVE, based on VIN analysis, that indicate a car is equipped with frontal air bags and the driver or right-front seats, respectively. PS208I includes any installation from MY 1995 onwards, because the phase-in of automatic occupant protection began on September 1, 1994.

```
  IF CY GE 1990 AND MY GE 1991 AND
    (SEAT2=11 AND (PASSIVE IN (1,2,3,1090) OR UDAB=1))
    OR (SEAT2=13 AND (PASSIVE IN (2,3) OR UPAB=2)) THEN DO;
      IF 1991 LE MY LE 1994 THEN PV208I=1;
        ELSE IF MY GE 1995 THEN PS208I=1; END;

/* ------------------------------------------------------------------ */
/*  SPLITS CASES INTO SCENARIOS DEPENDING ON AIR BAG TYPE, SEAT POS,  */
/*  ON-OFF SWITCH PRESENCE, OCCUPANT AGE, RESTRAINT USE               */
/*  COMPUTES LIVES SAVED BY AIR BAGS IN EACH SCENARIO                 */
/* ------------------------------------------------------------------ */
```

For LTV occupants, there can be eight different effectiveness scenarios – belted drivers, unbelted drivers, child passengers in LTVs (primarily pickup trucks) with on-off switches, child passengers in LTVs (primarily SUVs and vans) without on-off switches, belted adult (age 13+) passengers with switches, belted adult passengers without switches, unbelted adult passengers with switches and unbelted adult passengers without switches – plus the default scenario, no air bag. Within each scenario, there are several effectiveness estimates.

```
  IF PS208I=0 AND PV208I=0 THEN GOTO TNOBAG;                  /* NO AIR BAG */
    ELSE IF SEAT2=11 AND REST3 GT 0 THEN GOTO TDRVBELT;       /* BELTED DRIVER */
    ELSE IF SEAT2=11 THEN GOTO TDRVUNR;                       /* UNRESTRAINED DRIVER */
    ELSE IF PASSIVE=3 AND 0 LE AGE LE 12 THEN GOTO TKIDSW;    /* CHILD RF WITH SWITCH */
    ELSE IF 0 LE AGE LE 12 THEN GOTO TKID;                    /* CHILD RF NO SWITCH */
    ELSE IF PASSIVE=3 AND REST3 GT 0 THEN GOTO TRFBELSW;      /* BELTED ADULT RF W SWITCH */
    ELSE IF PASSIVE=3 THEN GOTO TRFUNRSW;                     /* UNBELTED ADULT RF W SWITCH */
    ELSE IF REST3 GT 0 THEN GOTO TRFBELT;                     /* BELTED ADULT RF NO SWITCH */
    ELSE GOTO TRFUNR;                                         /* UNBELTED ADULT RF NO SWITCH */
```

In addition to the basic statistics, WEIGHTFA, TLS208I, TLV208I and TL208I, the model compiles more detailed information on air bags:

- TABDRV = LTV driver lives saved by air bags
- TABRF = adult (age 13+) passenger lives saved by air bags in LTVs without on-off switches
- TABKID = effect of air bags on child (age 0-12) passengers in LTVs without switches; if this is a fatality increase, it will show up as a negative number.
- SW0 = actual effect of air bags on adult passengers in pickup trucks with switches: number of lives saved by air bags because the switch was left "on" for the adult
- SW1 = potential number of adult passenger lives saved in these pickup trucks if the switch had always been "on" for adults (or if the trucks had passenger air bags but no switches)
- SW2 = SW0 – SW1 = potential savings not realized because the switches were "off" for some adults. This will be a negative number.
- SWKID0 = actual (harmful) effect of air bags on child passengers in pickup trucks with switches that were left "on" for the child. This will be a negative number, because a fatality increase is a negative number of lives saved.
- SWKID1 = potential (harmful) effect of air bags on child passengers in pickup trucks if those trucks had been equipped with dual air bags and no switches. This will be a more negative number than SWKID0.
- SWKID2 = SWKID0 – SWKID1 = child passengers avoiding potentially fatal injury from air bags because the switches were available and appropriately turned "off" for the children. This will be a positive number.

```
TNOBAG:    TLS208I=0; TLV208I=0; TL208I=0;
    TABDRV=0; TABRF=0; TABKID=0; SW0=0; SW1=0; SW2=0;
    SWKID0=0; SWKID1=0; SWKID2=0; GOTO T214;
```

NHTSA's evaluation found that air bags have about the same effect in LTVs as in cars.

```
TDRVBELT:  OLDWTFA=WEIGHTFA;
    IF 1 LE M_HARM LE 6 THEN E=0;
      ELSE IF IMPACT2=12 THEN E=.25258;
      ELSE IF IMPACT2 IN (1,11) THEN E=.13239;
      ELSE IF IMPACT2 IN (2,10) THEN E=.05052; ELSE E=0;
    P=PS208I+PV208I;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208I=S*PS208I/P;
    TLV208I=S*PV208I/P;
    WEIGHTFA=OLDWTFA+TLS208I+TLV208I;
    TL208I=TLS208I+TLV208I;
    TLS=TLS+TLS208I; TLV=TLV+TLV208I; TL=TL+TL208I;
    TABDRV=TL208I; TABRF=0; TABKID=0; SW0=0; SW1=0; SW2=0;
    SWKID0=0; SWKID1=0; SWKID2=0; GOTO T214;
```

```
TDRVUNR:   OLDWTFA=WEIGHTFA;
    IF 1 LE M_HARM LE 6 THEN E=0;
      ELSE IF IMPACT2=12 THEN E=.32742;
      ELSE IF IMPACT2 IN (1,11) THEN E=.17161;
      ELSE IF IMPACT2 IN (2,10) THEN E=.06548; ELSE E=0;
    P=PS208I+PV208I;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208I=S*PS208I/P;
    TLV208I=S*PV208I/P;
    WEIGHTFA=OLDWTFA+TLS208I+TLV208I;
    TL208I=TLS208I+TLV208I;
    TLS=TLS+TLS208I; TLV=TLV+TLV208I; TL=TL+TL208I;
    TABDRV=TL208I; TABRF=0; TABKID=0; SW0=0; SW1=0; SW2=0;
    SWKID0=0; SWKID1=0; SWKID2=0; GOTO T214;

TRFBELT:   OLDWTFA=WEIGHTFA;
    IF 1 LE M_HARM LE 6 THEN E=0;
      ELSE IF IMPACT2=12 THEN E=.27784;
      ELSE IF IMPACT2 IN (1,11) THEN E=.14563;
      ELSE IF IMPACT2 IN (2,10) THEN E=.05557; ELSE E=0;
    P=PS208I+PV208I;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208I=S*PS208I/P;
    TLV208I=S*PV208I/P;
    WEIGHTFA=OLDWTFA+TLS208I+TLV208I;
    TL208I=TLS208I+TLV208I;
    TLS=TLS+TLS208I; TLV=TLV+TLV208I; TL=TL+TL208I;
    TABDRV=0; TABRF=TL208I; TABKID=0; SW0=0; SW1=0; SW2=0;
    SWKID0=0; SWKID1=0; SWKID2=0; GOTO T214;

TRFUNR:    OLDWTFA=WEIGHTFA;
    IF 1 LE M_HARM LE 6 THEN E=0;
      ELSE IF IMPACT2=12 THEN E=.36016;
      ELSE IF IMPACT2 IN (1,11) THEN E=.18877;
      ELSE IF IMPACT2 IN (2,10) THEN E=.07203; ELSE E=0;
    P=PS208I+PV208I;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208I=S*PS208I/P;
    TLV208I=S*PV208I/P;
    WEIGHTFA=OLDWTFA+TLS208I+TLV208I;
    TL208I=TLS208I+TLV208I;
    TLS=TLS+TLS208I; TLV=TLV+TLV208I; TL=TL+TL208I;
    TABDRV=0; TABRF=TL208I; TABKID=0; SW0=0; SW1=0; SW2=0;
    SWKID0=0; SWKID1=0; SWKID2=0; GOTO T214;

TKID:      OLDWTFA=WEIGHTFA;
      IF KCRSH=1 AND RESTGP=1 THEN E=-4.5;
        ELSE IF KCRSH=1 AND RESTGP IN (2,3) THEN E=-1;
        ELSE IF KCRSH=1 AND RESTGP IN (4,5,6) THEN E=-.70;
        ELSE IF KCRSH IN (2,3) AND RESTGP=1 THEN E=-1.71;
        ELSE IF KCRSH IN (2,3) AND RESTGP IN (2,3) THEN E=-.38;
        ELSE IF KCRSH IN (2,3) AND RESTGP IN (4,5,6) THEN E=-.27;
        ELSE E=0;
    P=PS208I+PV208I;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208I=S*PS208I/P;
    TLV208I=S*PV208I/P;
    WEIGHTFA=OLDWTFA+TLS208I+TLV208I;
    TL208I=TLS208I+TLV208I;
    TLS=TLS+TLS208I; TLV=TLV+TLV208I; TL=TL+TL208I;
    TABDRV=0; TABRF=0; TABKID=TL208I; SW0=0; SW1=0; SW2=0;
    SWKID0=0; SWKID1=0; SWKID2=0; GOTO T214;

TRFBELSW:  OLDWTFA=WEIGHTFA;
    IF 1 LE M_HARM LE 6 THEN E=0;
```

```
      ELSE IF IMPACT2=12 THEN E=.27784;
      ELSE IF IMPACT2 IN (1,11) THEN E=.14563;
      ELSE IF IMPACT2 IN (2,10) THEN E=.05557; ELSE E=0;
```

For the three scenarios involving on-off switches, the additional parameter U indicates the use rate of the switches – i.e., the proportion of air bags turned ***off*** – as observed in NHTSA's survey of pickup trucks. U ranges from .15 for adults age 20-59 up to .86 for infants under age 1. (Ideally, though, U should be 0 for those adults and 1 for the infants.) When the switch is "used," the air bag is off, and it has no effect on fatality risk. The effect of air bags is (1-U)E.

```
  /* USE RATES FOR ON-OFF SWITCHES BY PASSENGER AGE                          */
    IF 13 LE AGE LE 15 THEN U=.22;
      ELSE IF 16 LE AGE LE 19 THEN U=.17;
      ELSE IF 20 LE AGE LE 59 THEN U=.15;
      ELSE IF 60 LE AGE LE 69 THEN U=.19;
      ELSE IF AGE GE 70 THEN U=.56;

    P=PS208I+PV208I;
    X=OLDWTFA/(1 - E*P + U*E*P);
    S=X - OLDWTFA;
    TLS208I=S*PS208I/P;
    TLV208I=S*PV208I/P;
    WEIGHTFA=OLDWTFA+TLS208I+TLV208I;
    Y=X*(1-E);
    SW1=X-Y;
    SW2=Y-OLDWTFA;
    TL208I=TLS208I+TLV208I;
    TLS=TLS+TLS208I; TLV=TLV+TLV208I; TL=TL+TL208I;
    SW0=TL208I;
    SWKID0=0; SWKID1=0; SWKID2=0; TABDRV=0; TABRF=0; TABKID=0; GOTO T214;

TRFUNRSW:  OLDWTFA=WEIGHTFA;
    IF 1 LE M_HARM LE 6 THEN E=0;
      ELSE IF IMPACT2=12 THEN E=.36016;
      ELSE IF IMPACT2 IN (1,11) THEN E=.18877;
      ELSE IF IMPACT2 IN (2,10) THEN E=.07203; ELSE E=0;

  /* USE RATES FOR ON-OFF SWITCHES BY PASSENGER AGE                          */
    IF 13 LE AGE LE 15 THEN U=.22;
      ELSE IF 16 LE AGE LE 19 THEN U=.17;
      ELSE IF 20 LE AGE LE 59 THEN U=.15;
      ELSE IF 60 LE AGE LE 69 THEN U=.19;
      ELSE IF AGE GE 70 THEN U=.56;

    P=PS208I+PV208I;
    X=OLDWTFA/(1 - E*P + U*E*P);
    S=X - OLDWTFA;
    TLS208I=S*PS208I/P;
    TLV208I=S*PV208I/P;
    WEIGHTFA=OLDWTFA+TLS208I+TLV208I;
    Y=X*(1-E);
    SW1=X-Y;
    SW2=Y-OLDWTFA;
    TL208I=TLS208I+TLV208I;
    TLS=TLS+TLS208I; TLV=TLV+TLV208I; TL=TL+TL208I;
    SW0=TL208I;
    SWKID0=0; SWKID1=0; SWKID2=0; TABDRV=0; TABRF=0; TABKID=0; GOTO T214;

TKIDSW:    OLDWTFA=WEIGHTFA;
      IF KCRSH=1 AND RESTGP=1 THEN E=-4.5;
        ELSE IF KCRSH=1 AND RESTGP IN (2,3) THEN E=-1;
        ELSE IF KCRSH=1 AND RESTGP IN (4,5,6) THEN E=-.70;
        ELSE IF KCRSH IN (2,3) AND RESTGP=1 THEN E=-1.71;
        ELSE IF KCRSH IN (2,3) AND RESTGP IN (2,3) THEN E=-.38;
```

```
        ELSE IF KCRSH IN (2,3) AND RESTGP IN (4,5,6) THEN E=-.27;
        ELSE E=0;

  /* USE RATES FOR ON-OFF SWITCHES BY PASSENGER AGE                        */
    IF AGE=0 THEN U=.86;
      ELSE IF 1 LE AGE LE 6 THEN U=.74;
      ELSE IF 7 LE AGE LE 8 THEN U=.59;
      ELSE IF 9 LE AGE LE 10 THEN U=.47;
      ELSE IF 11 LE AGE LE 12 THEN U=.30;

    P=PS208I+PV208I;
    X=OLDWTFA/(1 - E*P + U*E*P);
    S=X - OLDWTFA;
    TLS208I=S*PS208I/P;
    TLV208I=S*PV208I/P;
    WEIGHTFA=OLDWTFA+TLS208I+TLV208I;
    Y=X*(1-E);
    SWKID1=X-Y;
    SWKID2=Y-OLDWTFA;
    TL208I=TLS208I+TLV208I;
    TLS=TLS+TLS208I; TLV=TLV+TLV208I; TL=TL+TL208I;
    SWKID0=TL208I;
    SW0=0; SW1=0; SW2=0; TABDRV=0; TABRF=0; TABKID=0;

/* ------------------------------------------------------------------ */
/*  214A SIDE DOOR BEAMS                                              */
/*  MEDIAN INSTALLATION YEAR: 1994                                    */
/* ------------------------------------------------------------------ */
```

Side door beams were introduced in a few LTV models in 1991-93. All MY 1994 LTVs were equipped with them.

```
/* IDENTIFIES LIGHT TRUCKS WITH SIDE DOOR BEAMS                       */
T214: PS214A=0; PV214A=0;
  IF MY LE 1990 THEN GOTO SAVE214T;
  IF MY GE 1994 THEN DO; PS214A=1; GOTO SAVE214T; END;
  IF CG IN (12303,12304,18405,49402) AND 1991 LE MY LE 1993 THEN DO;
      PV214A=1; GOTO SAVE214T; END;
  IF CG=12404 AND 1992 LE MY LE 1993 THEN DO; PV214A=1; GOTO SAVE214T; END;
  IF CG IN (12405,35203,35204,35301,49303) AND MY=1993 THEN DO;
      PV214A=1; GOTO SAVE214T; END;
  IF 1201 LE CG LE 63401 THEN GOTO SAVE214T;
  IF MAKE IN (12,14,20,21,22,35,41,49) THEN GOTO SOMEVOLT; GOTO SAVE214T;

SOMEVOLT: IF MAK_MOD IN (12401,41401,20442,21441,22441,49441)
    AND 1991 LE MY LE 1993 THEN DO; PV214A=1; GOTO SAVE214T; END;
IF MAK_MOD=12461 AND 1992 LE MY LE 1993 THEN DO; PV214A=1; GOTO SAVE214T; END;
IF MAK_MOD IN (14443,35443,35471,35401,49421) AND MY=1993 THEN DO;
    PV214A=1; GOTO SAVE214T; END;

/* REDUCTION IN SINGLE-VEHICLE SIDE-IMPACT FATALITIES WITH SIDE DOOR BEAMS     */
SAVE214T: OLDWTFA=WEIGHTFA;
```

NHTSA's evaluation showed side door beams are effective for outboard occupants in single-vehicle side-impact crashes. Fatality reduction is 26 percent for nearside occupants and 11 percent for farside occupants.

```
  IF (PS214A GT 0 OR PV214A GT 0) AND CRSH=2 AND
      SEAT2 IN (11,13,21) AND VE_FORMS=1 THEN DO;
  IF (SEAT_POS IN (11,21) AND IMPACT2 IN (8,9,10)) OR
       (SEAT_POS IN (13,23) AND IMPACT2 IN (2,3,4)) THEN E=.25; ELSE E=.11;
    P=PS214A+PV214A;
    S=OLDWTFA*E*P / (1 - E*P);
```

```
    TLS214A=S*PS214A/P;
    TLV214A=S*PV214A/P;
    WEIGHTFA=OLDWTFA+TLS214A+TLV214A; END;
  ELSE DO; TLS214A=0; TLV214A=0; END;
  TL214A=TLS214A+TLV214A;
  TLS=TLS+TLS214A; TLV=TLV+TLV214A; TL=TL+TL214A;

/* ---------------------------------------------------------------- */
/*  208G 3-POINT BELTS FOR BACK-SEAT OUTBOARD OCCUPANTS             */
/*  MEDIAN INSTALLATION YEAR: 1990                                  */
/* ---------------------------------------------------------------- */

/* IDENTIFIES BACK-SEAT OUTBOARD OCCUPANTS WEARING 3-POINT BELTS  */
  PS208G=0; PV208G=0;
  IF SEAT2=21 AND REST3=3 THEN DO; IF MY LE 1991 THEN PV208G=1; ELSE PS208G=1; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY BACK-SEAT OUTBOARD 3-POINT BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208G GT 0 OR PV208G GT 0 THEN DO;
```

Three-point belts in the rear-outboard seats reduce fatality risk by 50 percent in frontals, 84 percent in rollovers and 70 percent in side, rear and other impacts.

```
    IF CRSH=1 THEN DO; E=.50; EJECT2=.48; END;
      ELSE IF CRSH=2 THEN DO; E=.70; EJECT2=.59; END;
      ELSE IF CRSH=3 THEN DO; E=.84; EJECT2=.85; END;
      ELSE IF CRSH=4 THEN DO; E=.70; EJECT2=.58; END;
    P=PS208G+PV208G;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208G=S*PS208G/P;
    TLV208G=S*PV208G/P;
    WEIGHTFA=OLDWTFA+TLS208G+TLV208G; END;
  ELSE DO; TLS208G=0; TLV208G=0; END;
  TL208G=TLS208G+TLV208G;
  TLS=TLS+TLS208G; TLV=TLV+TLV208G; TL=TL+TL208G;

/* ---------------------------------------------------------------- */
/*  213 CHILD SAFETY SEATS                                          */
/*  USE RATE WENT OVER 50% IN: 1985                                 */
/* ---------------------------------------------------------------- */

/* IDENTIFIES CHILD PASSENGERS IN SAFETY SEATS  */
  PS213=0; PV213=0;
  IF REST3=4 THEN DO;
    IF STATE=47 AND CY GE 1978 AND AGE LE 3 THEN PS213=1;
      ELSE IF STATE=44 AND CY GE 1980 AND AGE LE 5 THEN PS213=1;
      ELSE IF STATE=54 AND CY GE 1981 AND AGE LE 2 THEN PS213=1;
      ELSE IF STATE=25 AND CY GE 1982 AND AGE LE 5 THEN PS213=1;
      ELSE IF STATE IN (9,10,20,21,26,36,37) AND CY GE 1982 AND AGE LE 3 THEN PS213=1;
      ELSE IF STATE IN (32,34,35) AND CY GE 1983 AND AGE LE 4 THEN PS213=1;
      ELSE IF STATE IN (1,6,11,12,17,28,33,39,45,51,55) AND CY GE 1983 AND AGE LE 3 THEN PS213=1;
      ELSE IF STATE=15 AND CY GE 1983 AND AGE LE 2 THEN PS213=1;
      ELSE IF STATE IN (4,5,46,50) AND CY GE 1984 AND AGE LE 4 THEN PS213=1;
      ELSE IF STATE IN (8,18,23,24,27,29,31,40,41,42) AND CY GE 1984 AND AGE LE 3 THEN PS213=1;
      ELSE IF STATE IN (13,38,53) AND CY GE 1984 AND AGE LE 2 THEN PS213=1;
      ELSE IF STATE IN (30,49) AND CY GE 1984 AND AGE LE 1 THEN PS213=1;
      ELSE IF STATE=56 AND CY GE 1985 AND AGE LE 4 THEN PS213=1;
      ELSE IF STATE IN (2,16) AND CY GE 1985 AND AGE LE 3 THEN PS213=1;
      ELSE IF STATE IN (19,22) AND CY GE 1985 AND AGE LE 2 THEN PS213=1;
      ELSE IF STATE=48 AND CY GE 1985 AND AGE LE 1 THEN PS213=1;
      ELSE PV213=1; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY CHILD SAFETY SEATS */
  OLDWTFA=WEIGHTFA;
  IF PS213 GT 0 OR PV213 GT 0 THEN DO;
```

NHTSA's evaluation estimates that safety seats reduce fatality risk by 58 percent for infants and by 59 percent for toddlers. Effectiveness is not estimated separately by crash mode. In general, 34 percent of unrestrained child passenger fatalities in frontal crashes were ejected, 48 percent in side impacts, 79 percent in rollovers and 42 percent in rear/other impacts.

```
    IF AGE=0 THEN E=.58; ELSE E=.59;
    IF CRSH=1 THEN EJECT2=.34;
      ELSE IF CRSH=2 THEN EJECT2=.48;
      ELSE IF CRSH=3 THEN EJECT2=.79;
      ELSE IF CRSH=4 THEN EJECT2=.42;
    P=PS213+PV213;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS213=S*PS213/P;
    TLV213=S*PV213/P;
    WEIGHTFA=OLDWTFA+TLS213+TLV213; END;
  ELSE DO; TLS213=0; TLV213=0; END;
  TL213=TLS213+TLV213;
  TLS=TLS+TLS213; TLV=TLV+TLV213; TL=TL+TL213;

/* ------------------------------------------------------------------ */
/*  212 ADHESIVE WINDSHIELD BONDING                                   */
/*  MEDIAN INSTALLATION YEAR: 1980                                    */
/* ------------------------------------------------------------------ */

/* IDENTIFIES LIGHT TRUCKS WITH ADHESIVE WINDSHIELD BONDING       */
```

FMVSS 212 took effect in LTVs on September 1, 1978. However, many LTVs had rubber gasket installations that complied with the standard. The transition to adhesive bonding began shortly before the standard and continued for several years afterward.

```
  IF MY LE 1977 THEN DO; PS212=0; PV212=0; END;
    ELSE IF MY GE 1985 THEN DO; PS212=1; PV212=0; END;
    ELSE IF MY=1978 THEN DO; PS212=0; PV212=.2; END;
    ELSE IF MY=1979 THEN DO; PS212=.4; PV212=0; END;
    ELSE IF MY=1980 THEN DO; PS212=.5; PV212=0; END;
    ELSE IF MY=1981 THEN DO; PS212=.6; PV212=0; END;
    ELSE IF MY=1982 THEN DO; PS212=.7; PV212=0; END;
    ELSE IF MY=1983 THEN DO; PS212=.8; PV212=0; END;
    ELSE IF MY=1984 THEN DO; PS212=.9; PV212=0; END;
/* REDUCTION IN EJECTION FATALITY RISK WITH ADHESIVE WINDSHIELD BONDING */
  OLDWTFA=WEIGHTFA;
```

NCSS data show that the proportion of ejections that are via the windshield portal is about the same in LTVs with rubber gaskets as in cars with rubber gaskets. We will assume that adhesive bonding has the same percentage effect on ejection fatalities in LTVs as in cars.

```
  IF (PS212 GT 0 OR PV212 GT 0) AND SEAT2 IN (11,12,13,18) AND EJECT2 NE 0 THEN DO;
    IF CRSH IN (1,3) THEN E=.033;
      ELSE IF CRSH IN (2,4) THEN E=.0075;
    P=PS212+PV212;
    REL_S=EJECT2*E*P / (1 - E*P);
    S=OLDWTFA*REL_S;
    TLS212=S*PS212/P;
    TLV212=S*PV212/P;
    WEIGHTFA=OLDWTFA+TLS212+TLV212;
    EJECT2=(EJECT2 + REL_S)/(1 + REL_S); END;
  ELSE DO; TLS212=0; TLV212=0; END;
  TL212=TLS212+TLV212;
  TLS=TLS+TLS212; TLV=TLV+TLV212; TL=TL+TL212;

/* ------------------------------------------------------------------ */
```

```
/*  208F 3-POINT BELTS FOR FRONT-SEAT OUTBOARD OCCUPANTS             */
/*  MEDIAN INSTALLATION YEAR: 1976                                   */
/* ----------------------------------------------------------------- */

/* IDENTIFIES FRONT-SEAT OCCUPANTS WEARING 3-POINT BELTS  */
  PS208F=0; PV208F=0;
  IF SEAT2 IN (11,13) AND REST3=3 THEN DO; IF MY LE 1976 THEN PV208F=1;
    ELSE IF 1977 LE MY LE 1981 AND NEWVTYP IN (12,13) THEN PV208F=1;
    ELSE PS208F=1; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY FRONT-OUTBOARD 3-POINT BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208F GT 0 OR PV208F GT 0 THEN DO;
```

In LTVs, 3-point belts reduce fatality risk by 64 percent in single-vehicle frontals, 40 percent in multivehicle frontals; 47 percent in single-vehicle nearside; 36 percent in multivehicle nearside; 61 percent in single-vehicle farside; 54 percent in multivehicle farside; 80 percent in rollovers; and 81 percent in rear/other impacts.

```
    IF CRSH=1 AND VE_FORMS=1 THEN DO; E=.64; EJECT2=.42; END;
      ELSE IF CRSH=1 THEN DO; E=.40; EJECT2=.24; END;
      ELSE IF CRSH=2 THEN DO;
        IF VE_FORMS=1 AND
          ((SEAT2=11 AND IMPACT2 IN (8,9,10)) OR (SEAT2=13 AND IMPACT2 IN (2,3,4)))
          THEN DO; E=.47; EJECT2=.44; END;
        ELSE IF ((SEAT2=11 AND IMPACT2 IN (8,9,10)) OR (SEAT2=13 AND IMPACT2 IN (2,3,4)))
          THEN DO; E=.36; EJECT2=.37; END;
        ELSE IF VE_FORMS=1 THEN DO; E=.61; EJECT2=.49; END;
        ELSE DO; E=.54; EJECT2=.41; END; END;
      ELSE IF CRSH=3 THEN DO; E=.80; EJECT2=.77; END;
      ELSE IF CRSH=4 THEN DO; E=.81; EJECT2=.51; END;
    P=PS208F+PV208F;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208F=S*PS208F/P;
    TLV208F=S*PV208F/P;
    WEIGHTFA=OLDWTFA+TLS208F+TLV208F; END;
  ELSE DO; TLS208F=0; TLV208F=0; END;
  TL208F=TLS208F+TLV208F;
  TLS=TLS+TLS208F; TLV=TLV+TLV208F; TL=TL+TL208F;

/* ----------------------------------------------------------------- */
/*  203 ENERGY-ABSORBING AND TELESCOPING STEERING ASSEMBLIES         */
/*  MEDIAN IMPLEMENTATION YEAR: EARLY 1976                           */
/* ----------------------------------------------------------------- */

/* IDENTIFIES LIGHT TRUCKS WITH ENERGY-ABSORBING STEERING ASSEMBLIES     */
  PS203=0; PV203=0;
  IF MY GE 1970 AND SEAT2=11 THEN DO;
```

The introduction date for energy-absorbing steering assemblies in LTVs depends on the manufacturer and the truck type (pickup, SUV or van).

```
      IF MY GE 1982 THEN PS203=1;
        ELSE IF MAKE=30 THEN PV203=1;
        ELSE IF MAKE IN (2,20,23) AND MY GE 1973 THEN PV203=1;
        ELSE IF MAKE IN (7,9) AND NEWVTYP IN (11,12) AND MY GE 1977 THEN PV203=1;
        ELSE IF MAKE IN (7,9) AND MY GE 1979 THEN PV203=1;
        ELSE IF MAKE=12 AND NEWVTYP IN (11,12) AND MY GE 1980 THEN PV203=1; END;
/* LIVES SAVED IN FRONTAL IMPACTS BY INSTRUMENT PANEL IMPROVEMENTS */
  OLDWTFA=WEIGHTFA;
  IF PS203 GT 0 OR PV203 GT 0 THEN DO;
```

NHTSA's evaluations suggest that energy-absorbing steering assemblies are about equally effective in LTVs and cars.

```
    IF IMPACT2 IN (11,12,1) THEN E=.121; ELSE E=0;
    P=PS203+PV203;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS203=S*PS203/P;
    TLV203=S*PV203/P;
    WEIGHTFA=OLDWTFA+TLS203+TLV203; END;
  ELSE DO; TLS203=0; TLV203=0; END;
  TL203=TLS203+TLV203;
  TLS=TLS+TLS203; TLV=TLV+TLV203; TL=TL+TL203;

/* ------------------------------------------------------------------ */
/*  201 VOLUNTARY INSTRUMENT PANEL IMPROVEMENTS (FMVSS-201 INSPIRED)  */
/*  MEDIAN IMPLEMENTATION YEAR: 1972                                  */
/* ------------------------------------------------------------------ */

/* INSTRUMENT PANELS WERE GRADUALLY IMPROVED FROM 1969 TO 1977    */
  PS201=0; PV201=0;
```

NHTSA's evaluation suggests that LTVs received the same types of instrument panel modifications as cars, and that they were gradually introduced, perhaps over a 1969-77 timeframe. NHTSA has no details about specific make-models.

```
  IF MY GE 1969 AND SEAT2=13 THEN DO;
      IF MY GE 1977 THEN PV201=1;
        ELSE PV201=.125*(MY-1968); END;
/* LIVES SAVED IN FRONTAL IMPACTS BY INSTRUMENT PANEL IMPROVEMENTS */
  OLDWTFA=WEIGHTFA;
  IF PS201 GT 0 OR PV201 GT 0 THEN DO;
```

NHTSA's evaluation found the instrument panel improvements to be about equally effective in LTVs and cars.

```
    IF CRSH=1 AND REST3 NE 2 THEN E=.159; ELSE E=0;
    P=PS201+PV201;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS201=S*PS201/P;
    TLV201=S*PV201/P;
    WEIGHTFA=OLDWTFA+TLS201+TLV201; END;
  ELSE DO; TLS201=0; TLV201=0; END;
  TL201=TLS201+TLV201;
  TLS=TLS+TLS201; TLV=TLV+TLV201; TL=TL+TL201;

/* ------------------------------------------------------------------ */
/*  105B FRONT DISC BRAKES                                            */
/*  MEDIAN INSTALLATION YEAR: 1971 (INSTALLATION COMPLETED 1977)      */
/* ------------------------------------------------------------------ */

/* IMPLEMENTATION OF FRONT DISC BRAKES */
```

We believe the timeframe for introducing front disc brakes was approximately the same for LTVs as cars; we are using the same implementation schedule as for cars. (However, FMVSS 105 was not extended to LTVs until September 1, 1983.)

```
  IF MY GE 1984 THEN DO; PS105B=1; PV105B=0; END;
    ELSE IF MY LE 1964 THEN DO; PS105B=0; PV105B=0; END;
    ELSE IF MY=1965 THEN DO; PS105B=0; PV105B=.02; END;
    ELSE IF MY=1966 THEN DO; PS105B=0; PV105B=.03; END;
    ELSE IF MY=1967 THEN DO; PS105B=0; PV105B=.06; END;
```

```
    ELSE IF MY=1968 THEN DO; PS105B=0; PV105B=.13; END;
    ELSE IF MY=1969 THEN DO; PS105B=0; PV105B=.28; END;
    ELSE IF MY=1970 THEN DO; PS105B=0; PV105B=.41; END;
    ELSE IF MY=1971 THEN DO; PS105B=0; PV105B=.63; END;
    ELSE IF MY=1972 THEN DO; PS105B=0; PV105B=.74; END;
    ELSE IF MY=1973 THEN DO; PS105B=0; PV105B=.86; END;
    ELSE IF MY=1974 THEN DO; PS105B=0; PV105B=.84; END;
    ELSE IF MY=1975 THEN DO; PS105B=0; PV105B=.93; END;
    ELSE IF MY=1976 THEN DO; PS105B=0; PV105B=.99; END;
    ELSE IF 1977 LE MY LE 1983 THEN DO; PS105B=0; PV105B=1; END;

/* LIGHT TRUCK OCCUPANT LIVES SAVED BY FRONT DISC BRAKES */
  OLDWTFA=WEIGHTFA;
  IF PS105B GT 0 OR PV105B GT 0 THEN DO;
    E=.0017;
    P=PS105B+PV105B;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS105B=S*PS105B/P;
    TLV105B=S*PV105B/P;
    WEIGHTFA=OLDWTFA+TLS105B+TLV105B; END;
  ELSE DO; TLS105B=0; TLV105B=0; END;
  TL105B=TLS105B+TLV105B;
  TLS=TLS+TLS105B; TLV=TLV+TLV105B; TL=TL+TL105B;
/* ------------------------------------------------------------------ */
/*  208E LAP BELTS FOR BACK-SEAT CENTER OCCUPANTS                     */
/*  MEDIAN INSTALLATION YEAR: 1968                                    */
/* ------------------------------------------------------------------ */

/* IDENTIFIES BACK-CENTER-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208E=0; PV208E=0;
  IF SEAT2=22 AND REST3=2 AND (5 LE AGE LE 99 OR AGE=.) THEN DO;
```

The original FMVSS 208 requirement for lap belts at all designated seating positions was extended to LTVs effective July 1, 1971.

```
     IF MY GE 1972 THEN PS208E=1;
       ELSE IF MY LE 1970 THEN PV208E=1;
       ELSE IF MY=1971 THEN DO; PS208E=.17; PV208E=.83; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY BACK-CENTER-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208E GT 0 OR PV208E GT 0 THEN DO;
```

Lap belts in the rear-outboard seats reduce fatality risk by 44 percent in frontals, 80 percent in rollovers and 64 percent in side, rear and other impacts. The same effectiveness is assumed for the rear-center seat.

```
    IF CRSH=1 THEN DO; E=.44; EJECT2=.49; END;
      ELSE IF CRSH=2 THEN DO; E=.64; EJECT2=.59; END;
      ELSE IF CRSH=3 THEN DO; E=.80; EJECT2=.85; END;
      ELSE IF CRSH=4 THEN DO; E=.64; EJECT2=.58; END;
    P=PS208E+PV208E;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208E=S*PS208E/P;
    TLV208E=S*PV208E/P;
    WEIGHTFA=OLDWTFA+TLS208E+TLV208E; END;
  ELSE DO; TLS208E=0; TLV208E=0; END;
  TL208E=TLS208E+TLV208E;
  TLS=TLS+TLS208E; TLV=TLV+TLV208E; TL=TL+TL208E;
```

Even though lap belts for rear-center occupants and the next two technologies, lap belts for front-center occupants and lap belts for rear-outboard occupants have approximately the same median implementation year in LTVs, 1968, it makes no difference what their sequential order is in the

model. Only one of these technologies can apply to any occupant: a properly seated, belted person cannot be in two different seat positions at the same time.

```
/* ---------------------------------------------------------------- */
/*  208D LAP BELTS FOR FRONT-SEAT CENTER OCCUPANTS                  */
/*  MEDIAN INSTALLATION YEAR: 1968                                  */
/* ---------------------------------------------------------------- */

/* IDENTIFIES FRONT-CENTER-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208D=0; PV208D=0;
  IF SEAT2=12 AND REST3=2 AND (5 LE AGE LE 99 OR AGE=.) THEN DO;
     IF MY GE 1972 THEN PS208D=1;
       ELSE IF MY LE 1970 THEN PV208D=1;
       ELSE IF MY=1971 THEN DO; PS208D=.17; PV208D=.83; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY FRONT-CENTER-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208D GT 0 OR PV208D GT 0 THEN DO;
```

A double-pair comparison analysis of lap belt effectiveness for front-outboard occupants, conducted in support of this study, found that lap belts reduce fatality risk by 48 percent in LTVs. There were not enough data for separate effectiveness estimates by crash mode. This effectiveness will also be assumed for the front-center occupant.

```
    E=.48;
    IF CRSH=1 THEN EJECT2=.33; ELSE IF CRSH=2 THEN EJECT2=.38;
      ELSE IF CRSH=3 THEN EJECT2=.72; ELSE IF CRSH=4 THEN EJECT2=.53;
    P=PS208D+PV208D;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208D=S*PS208D/P;
    TLV208D=S*PV208D/P;
    WEIGHTFA=OLDWTFA+TLS208D+TLV208D; END;
  ELSE DO; TLS208D=0; TLV208D=0; END;
  TL208D=TLS208D+TLV208D;
  TLS=TLS+TLS208D; TLV=TLV+TLV208D; TL=TL+TL208D;

/* ---------------------------------------------------------------- */
/*  208C LAP BELTS FOR BACK-SEAT OUTBOARD OCCUPANTS                 */
/*  MEDIAN INSTALLATION YEAR: 1968                                  */
/* ---------------------------------------------------------------- */

/* IDENTIFIES BACK-OUTBOARD-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208C=0; PV208C=0;
  IF SEAT2=21 AND REST3=2 AND (5 LE AGE LE 99 OR AGE=.) THEN DO;
     IF MY GE 1972 THEN PS208C=1;
       ELSE IF MY LE 1970 THEN PV208C=1;
       ELSE IF MY=1971 THEN DO; PS208C=.17; PV208C=.83; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY BACK-OUTBOARD-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208C GT 0 OR PV208C GT 0 THEN DO;
```

Lap belts in the rear-outboard seats reduce fatality risk by 44 percent in frontals, 80 percent in rollovers and 64 percent in side, rear and other impacts.

```
    IF CRSH=1 THEN DO; E=.44; EJECT2=.48; END;
      ELSE IF CRSH=2 THEN DO; E=.64; EJECT2=.59; END;
      ELSE IF CRSH=3 THEN DO; E=.80; EJECT2=.85; END;
      ELSE IF CRSH=4 THEN DO; E=.64; EJECT2=.58; END;
    P=PS208C+PV208C;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208C=S*PS208C/P;
    TLV208C=S*PV208C/P;
    WEIGHTFA=OLDWTFA+TLS208C+TLV208C; END;
```

```
ELSE DO; TLS208C=0; TLV208C=0; END;
TL208C=TLS208C+TLV208C;
TLS=TLS+TLS208C; TLV=TLV+TLV208C; TL=TL+TL208C;
```

```
/* ---------------------------------------------------------------- */
/*  206 DOOR LOCK IMPROVEMENTS                                      */
/*  MEDIAN INSTALLATION YEAR: 1967                                  */
/* ---------------------------------------------------------------- */

/* DOOR LOCKS IMPROVED GRADUALLY FROM 1962 TO 1972       */
```

FMVSS 206 took effect on January 1, 1972 in LTVs (and on January 1, 1968 in cars). Door lock improvements were gradually introduced in cars from MY 1962 until MY 1968, the year the standard took effect. We will assume that LTV door locks received comparable improvements, also starting about 1962 but extending until the 1972 effective date.

```
  IF MY GE 1973 THEN DO; PS206=1; PV206=0; END;
    ELSE IF MY=1972 THEN DO; PS206=.5; PV206=.5; END;
    ELSE IF 1962 LE MY LE 1971 THEN DO; PS206=0; PV206=(MY-1961)/11; END;
    ELSE IF MY LE 1961 THEN DO; PS206=0; PV206=0; END;
/* REDUCTION IN EJECTION ROLLOVER FATALITY RISK WITH IMPROVED DOOR LOCKS */
  OLDWTFA=WEIGHTFA;
  IF (PS206 GT 0 OR PV206 GT 0) AND (CRSH=3 OR M_HARM=1)
      AND SEAT2 NE 52 AND EJECT2 NE 0 THEN DO;
```

In passenger cars, the reduction of ejection fatalities in rollovers was 15.38 percent. However, in NCSS, 32.11 percent of ejection fatalities in rollovers in cars were through doors, but only 20.45 percent in LTVs. Thus, the effectiveness in LTVs is estimated to be (.2045/.3211) x .1538 = 9.8 percent (excluding occupants riding in the beds of pickups or elsewhere outside the passenger compartment).

```
    E=.098;
    P=PS206+PV206;
    REL_S=EJECT2*E*P / (1 - E*P);
    S=OLDWTFA*REL_S;
    TLS206=S*PS206/P;
    TLV206=S*PV206/P;
    WEIGHTFA=OLDWTFA+TLS206+TLV206;
    EJECT2=(EJECT2 + REL_S)/(1 + REL_S); END;
  ELSE DO; TLS206=0; TLV206=0; END;
  TL206=TLS206+TLV206;
  TLS=TLS+TLS206; TLV=TLV+TLV206; TL=TL+TL206;

/* ---------------------------------------------------------------- */
/*  105A DUAL MASTER CYLINDERS                                      */
/*  MEDIAN INSTALLATION YEAR: LATE 1966                             */
/* ---------------------------------------------------------------- */

/* IMPLEMENTATION OF DUAL MASTER CYLINDERS */
```

We believe the timeframe for introducing dual master cylinders was approximately the same for LTVs as cars; we are using the same implementation schedule as for cars. (However, FMVSS 105 was not extended to LTVs until September 1, 1983.)

```
  IF MY GE 1984 THEN DO; PS105A=1; PV105A=0; END;
    ELSE IF MY LE 1961 THEN DO; PS105A=0; PV105A=0; END;
    ELSE IF MY IN (1962,1963) THEN DO; PS105A=0; PV105A=.09; END;
    ELSE IF MY IN (1964,1965) THEN DO; PS105A=0; PV105A=.07; END;
    ELSE IF MY=1966 THEN DO; PS105A=0; PV105A=.54; END;
    ELSE IF 1967 LE MY LE 1983 THEN DO; PS105A=0; PV105A=1; END;
/* LIGHT TRUCK OCCUPANT LIVES SAVED BY DUAL MASTER CYLINDERS */
  OLDWTFA=WEIGHTFA;
  IF PS105A GT 0 OR PV105A GT 0 THEN DO;
    E=.007;
    P=PS105A+PV105A;
```

```
    S=OLDWTFA*E*P / (1 - E*P);
    TLS105A=S*PS105A/P;
    TLV105A=S*PV105A/P;
    WEIGHTFA=OLDWTFA+TLS105A+TLV105A; END;
  ELSE DO; TLS105A=0; TLV105A=0; END;
  TL105A=TLS105A+TLV105A;
  TLS=TLS+TLS105A; TLV=TLV+TLV105A; TL=TL+TL105A;

/* ------------------------------------------------------------------ */
/*  208B LAP BELT USE BY CHILDREN AGE 1-4                             */
/*  MEDIAN INSTALLATION YEAR FOR LAP BELTS USED BY CHILDREN: 1966     */
/* ------------------------------------------------------------------ */

/* IDENTIFIES CHILD PASSENGERS AGE 1-4 USING LAP BELTS */
  PS208B=0; PV208B=0;
  IF 1 LE AGE LE 4 AND REST3=2 THEN DO;
     IF MY GE 1972 THEN PS208B=1;
       ELSE IF MY LE 1970 THEN PV208B=1;
       ELSE IF MY=1971 THEN DO; PS208B=.17; PV208B=.83; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY LAP BELTS (AGE 1-4) */
  OLDWTFA=WEIGHTFA;
  IF PS208B GT 0 OR PV208B GT 0 THEN DO;
```

NHTSA's evaluation estimates that lap belts reduce fatality risk by 48 percent for toddlers in LTVs. Effectiveness is not estimated separately by crash mode.[7]

```
    E=.48;
    IF CRSH=1 THEN EJECT2=.34; ELSE IF CRSH=2 THEN EJECT2=.48;
      ELSE IF CRSH=3 THEN EJECT2=.79; ELSE IF CRSH=4 THEN EJECT2=.42;
    P=PS208B+PV208B;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208B=S*PS208B/P;
    TLV208B=S*PV208B/P;
    WEIGHTFA=OLDWTFA+TLS208B+TLV208B; END;
  ELSE DO; TLS208B=0; TLV208B=0; END;
  TL208B=TLS208B+TLV208B;
  TLS=TLS+TLS208B; TLV=TLV+TLV208B; TL=TL+TL208B;

/* ------------------------------------------------------------------ */
/*  208A LAP BELTS FOR FRONT-SEAT OUTBOARD OCCUPANTS                  */
/*  MEDIAN INSTALLATION YEAR: 1964                                    */
/* ------------------------------------------------------------------ */

/* IDENTIFIES FRONT-OUTBOARD-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208A=0; PV208A=0;
  IF SEAT2 IN (11,13) AND REST3=2 AND (5 LE AGE LE 99 OR AGE=.) THEN DO;
     IF MY GE 1972 THEN PS208A=1;
       ELSE IF MY LE 1970 THEN PV208A=1;
       ELSE IF MY=1971 THEN DO; PS208A=.17; PV208A=.83; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY FRONT-OUTBOARD-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208A GT 0 OR PV208A GT 0 THEN DO;
```

A double-pair comparison analysis of lap belt effectiveness for front-outboard occupants, conducted in support of this study, found that lap belts reduce fatality risk by 48 percent in LTVs. There were not enough data for separate effectiveness estimates by crash mode.

```
    E=.48;
    IF CRSH=1 THEN EJECT2=.34; ELSE IF CRSH=2 THEN EJECT2=.42;
```

[7] This evaluation is discussed in the "Child Safety Seats" section of the FMVSS 213 chapter of Part 1, not the FMVSS 208 chapter.

```
      ELSE IF CRSH=3 THEN EJECT2=.77; ELSE IF CRSH=4 THEN EJECT2=.51;
    P=PS208A+PV208A;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208A=S*PS208A/P;
    TLV208A=S*PV208A/P;
    WEIGHTFA=OLDWTFA+TLS208A+TLV208A; END;
  ELSE DO; TLS208A=0; TLV208A=0; END;
  TL208A=TLS208A+TLV208A;
  TLS=TLS+TLS208A; TLV=TLV+TLV208A; TL=TL+TL208A;
RUN;
```

That concludes the model for LTVs. It has estimated, on a case-by-case basis, by how much fatalities would increase if all the safety technologies were "removed" from vehicles. The next step is to tally up the lives saved over all the cases, by calendar year.

```
PROC MEANS SUM NOPRINT DATA=TRK2; BY CY;
  VAR ORIGWT WEIGHTFA
    TLV208J TLS208J TL208J
    TLV108 TLS108 TL108
    TLV208I TLS208I TL208I
    TLV214A TLS214A TL214A
    TLV208G TLS208G TL208G
    TLV213 TLS213 TL213
    TLV212 TLS212 TL212
    TLV208F TLS208F TL208F
    TLV203 TLS203 TL203
    TLV201 TLS201 TL201
    TLV105B TLS105B TL105B
    TLV208E TLS208E TL208E
    TLV208D TLS208D TL208D
    TLV208C TLS208C TL208C
    TLV206 TLS206 TL206
    TLV105A TLS105A TL105A
    TLV208B TLS208B TL208B
    TLV208A TLS208A TL208A
    TABDRV TABRF TABKID SW0 SW1 SW2
    SWKID0 SWKID1 SWKID2
    TLV TLS TL;
  OUTPUT OUT=TRK3
    SUM=T_ORIGWT T_WTFA
    TLV208J TLS208J TL208J
    TLV108 TLS108 TL108
    TLV208I TLS208I TL208I
    TLV214A TLS214A TL214A
    TLV208G TLS208G TL208G
    TLV213 TLS213 TL213
    TLV212 TLS212 TL212
    TLV208F TLS208F TL208F
    TLV203 TLS203 TL203
    TLV201 TLS201 TL201
    TLV105B TLS105B TL105B
    TLV208E TLS208E TL208E
    TLV208D TLS208D TL208D
    TLV208C TLS208C TL208C
    TLV206 TLS206 TL206
    TLV105A TLS105A TL105A
    TLV208B TLS208B TL208B
    TLV208A TLS208A TL208A
    TABDRV TABRF TABKID SW0 SW1 SW2
    SWKID0 SWKID1 SWKID2
    TLV TLS TL;
```

Prints the number of lives saved by each technology in each calendar year, and the sum of lives saved in 1975-2002.

```
PROC PRINT DATA=TRK3;
  FORMAT TLV208J TLS208J TL208J TLV108 TLS108 TL108 TLV208I TLS208I TL208I 9.0;
  ID CY; VAR TLV208J TLS208J TL208J TLV108 TLS108 TL108 TLV208I TLS208I TL208I;
  SUM TLV208J TLS208J TL208J TLV108 TLS108 TL108 TLV208I TLS208I TL208I;
TITLE1 'LIGHT TRUCK OCCUPANT LIVES SAVED BY BACK-CENTER 3-POINT BELTS, TRAILER CONSPICUITY TAPE,
AND AIR BAGS, 1975-2002';
TITLE2 ' ';
TITLE3 '...208J = 3-POINT BELTS FOR BACK-CENTER OCCUPANTS (MEDIAN INSTALLATION YEAR > 2001, FMVSS
PHASE-IN TO BEGIN 9/2005)';
TITLE4 '...108  = TRAILER CONSPICUITY TAPE (ON-ROAD FLEET 50% EQUIPPED 1996, FMVSS 12/1/93,
RETROFIT 6/1/2001)';
TITLE5 '...208I = FRONTAL AIR BAGS (MEDIAN INSTALLATION YEAR 1995, FMVSS PHASE-IN BEGAN 9/1/94)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, LIGHT TRUCKS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=TRK3;
  FORMAT TLV214A TLS214A TL214A TLV208G TLS208G TL208G TLV213 TLS213 TL213 9.0;
  ID CY; VAR TLV214A TLS214A TL214A TLV208G TLS208G TL208G TLV213 TLS213 TL213;
  SUM TLV214A TLS214A TL214A TLV208G TLS208G TL208G TLV213 TLS213 TL213;
TITLE1 'LIGHT TRUCK OCCUPANT LIVES SAVED BY SIDE DOOR BEAMS, BACK-OUTBOARD 3-POINT BELTS, AND CHILD
SAFETY SEATS, 1975-2002';
TITLE2 ' ';
TITLE3 '...214A = SIDE DOOR BEAMS (MEDIAN INSTALLATION YEAR 1994, FMVSS EFFECTIVE 9/1/93)';
TITLE4 '...208G = 3-POINT BELTS FOR BACK-SEAT OCCUPANTS (MEDIAN INSTALLATION YEAR 1990, FMVSS
EFFECTIVE 9/1/91)';
TITLE5 '...213  = CHILD SAFETY SEATS (USE EXCEEDED 50% IN 1985, FMVSS EFFECTIVE 4/1/71, STATE LAWS
1978-85)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, LIGHT TRUCKS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=TRK3;
  FORMAT TLV212 TLS212 TL212 TLV208F TLS208F TL208F TLV203 TLS203 TL203 9.0;
  ID CY; VAR TLV212 TLS212 TL212 TLV208F TLS208F TL208F TLV203 TLS203 TL203;
  SUM TLV212 TLS212 TL212 TLV208F TLS208F TL208F TLV203 TLS203 TL203;
TITLE1 'LIGHT TRUCK OCC LIVES SAVED BY ADHESIVE WINDSHIELD BONDING, FRONT-SEAT 3-POINT BELTS, AND
EA STEERING ASSEMBLIES, 1975-2002';
TITLE2 ' ';
TITLE3 '...212  = ADHESIVE WINDSHIELD BONDING (MEDIAN INSTALLATION YEAR 1979, FMVSS EFFECTIVE
9/1/78)';
TITLE4 '...208F = 3-POINT BELTS FOR FRONT-SEAT OCCUPANTS (MEDIAN INSTALLATION YEAR 1976, FMVSS
EFFECTIVE 1/1/76)';
TITLE5 '...203  = ENERGY-ABSORBING STEERING ASSEMBLIES (MEDIAN IMPLEMENTATION YEAR EARLY 1976,
FMVSS EFFECTIVE 9/1/81)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, LIGHT TRUCKS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=TRK3;
  FORMAT TLV201 TL201 TLV105B TLS105B TL105B TLV208E TLS208E TL208E 9.0;
  ID CY; VAR TLV201 TL201 TLV105B TLS105B TL105B TLV208E TLS208E TL208E;
  SUM TLV201 TL201 TLV105B TLS105B TL105B TLV208E TLS208E TL208E;
TITLE1 'LIGHT TRUCK OCCUPANT LIVES SAVED BY SAFER INSTRUMENT PANELS, FRONT DISC BRAKES, AND BACK-
CENTER LAP BELTS, 1975-2002';
TITLE2 ' ';
TITLE3 '...201  = VOLUNTARY INSTRUMENT PANEL IMPROVEMENTS (MEDIAN IMPLEMENTATION YEAR 1972, FMVSS
EFFECTIVE 9/1/81)';
TITLE4 '...105B = FRONT DISC BRAKES (MEDIAN INSTALLATION YEAR 1971, FMVSS EFFECTIVE 9/1/83)';
TITLE5 '...208E = LAP BELTS FOR BACK-CENTER OCCUPANTS (MEDIAN INSTALLATION YEAR 1968, FMVSS
EFFECTIVE 7/1/71)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, LIGHT TRUCKS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';
```

```
PROC PRINT DATA=TRK3;
  FORMAT TLV208D TLS208D TL208D TLV208C TLS208C TL208C TLV206 TLS206 TL206 9.0;
  ID CY; VAR TLV208D TLS208D TL208D TLV208C TLS208C TL208C TLV206 TLS206 TL206;
  SUM TLV208D TLS208D TL208D TLV208C TLS208C TL208C TLV206 TLS206 TL206;
TITLE1 'LIGHT TRUCK OCCUPANT LIVES SAVED BY FRONT-CENTER LAP BELTS, BACK-OUTBOARD LAP BELTS, AND
IMPROVED DOOR LOCKS, 1975-2002';
TITLE2 ' ';
TITLE3 '...208D = LAP BELTS FOR FRONT-CENTER OCCUPANTS (MEDIAN INSTALLATION YEAR 1968, FMVSS
EFFECTIVE 7/1/71)';
TITLE4 '...208C = LAP BELTS FOR BACK-OUTBOARD OCCUPANTS (MEDIAN INSTALLATION YEAR 1968, FMVSS
EFFECTIVE 7/1/71)';
TITLE5 '...206  = IMPROVED DOOR LOCKS (MEDIAN INSTALLATION YEAR 1967, FMVSS EFFECTIVE 1/1/72)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, LIGHT TRUCKS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=TRK3;
  FORMAT TLV105A TLS105A TL105A TLV208B TLS208B TL208B TLV208A TLS208A TL208A 9.0;
  ID CY; VAR TLV105A TLS105A TL105A TLV208B TLS208B TL208B TLV208A TLS208A TL208A;
  SUM TLV105A TLS105A TL105A TLV208B TLS208B TL208B TLV208A TLS208A TL208A;
TITLE1 'LIGHT TRUCK OCC LIVES SAVED BY DUAL MASTER CYLINDERS, LAP BELTS FOR CHILDREN AGE 1-4, AND
FRONT-OUTBOARD LAP BELTS, 1975-2002';
TITLE2 ' ';
TITLE3 '...105A = DUAL MASTER CYLINDERS (MEDIAN INSTALLATION YEAR LATE 1966, FMVSS EFFECTIVE
9/1/83)';
TITLE4 '...208B = LAP BELT USE BY CHILDREN AGE 1-4 (MEDIAN INSTALLATION YEAR 1966, FMVSS EFFECTIVE
7/1/71)';
TITLE5 '...208A = LAP BELTS FOR FRONT-OUTBOARD OCCUPANTS (MEDIAN INSTALLATION YEAR 1964, FMVSS
EFFECTIVE 7/1/71)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, LIGHT TRUCKS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

DATA TRK4; SET TRK3;
PCT_SAVE=100*TL/T_WTFA;
PROC PRINT DATA=TRK4;
  FORMAT T_ORIGWT T_WTFA TLV TLS TL 9.0 PCT_SAVE 6.2;
  ID CY; VAR T_ORIGWT T_WTFA TLV TLS TL PCT_SAVE;
  SUM T_ORIGWT T_WTFA TLV TLS TL;
TITLE1 'OVERALL LIGHT TRUCK OCCUPANT LIVES SAVED BY VEHICLE SAFETY STANDARDS AND TECHNOLOGIES,
1975-2002';
TITLE2 ' ';
TITLE3 'T_ORIGWT = ACTUAL LIGHT TRUCK OCCUPANT FATALITIES';
TITLE4 'T_WTFA = FATALITIES THAT WOULD HAVE OCCURRED WITHOUT ANY VEHICLE SAFETY IMPROVEMENTS';
TITLE5 'TLV = OVERALL LIVES SAVED BY VOLUNTARY IMPROVEMENTS, BEFORE FMVSS EFFECTIVE DATE';
TITLE6 'TLS = OVERALL LIVES SAVED IN LIGHT TRUCKS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';
TITLE7 'TL = OVERALL LIVES SAVED BY VEHICLE SAFETY IMPROVEMENTS (TLV + TLS)';
TITLE8 'PCT_SAVE = PERCENT OF WOULD-HAVE-BEEN FATALITIES SAVED BY SAFETY STANDARDS AND
TECHNOLOGIES';
RUN;


/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
/*  SUMMARY OF LIVES SAVED BY FMVSS FOR CARS, LIGHT TRUCKS & PEDS     */
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
```

Adds up the lives saved among car occupants, LTV occupants, non-occupants and motorcyclists. PCT_SAVE is the percent of potential car + LTV occupant fatalities saved.

```
DATA CTP3; MERGE CAR3 TRK3 PED3 MC3; BY CY;
SAVED=CL+TL+PL+ML;
VOL_SAVE=CLV+TLV+PLV+MLV;
STD_SAVE=CLS+TLS+PLS+MLS;
F_ACTUAL=C_ORIGWT+T_ORIGWT;
```

```
F_POTNTL=C_WTFA+T_WTFA;
PV_SAVE=CL+TL;
PCT_SAVE=100*PV_SAVE/F_POTNTL;
BELTS=CL208J+CL208H+CL208G+CLNCAP+CL208F+CL208E+CL208D+CL208C+CL208B+CL208A;
  BELTS=BELTS+TL208J+TL208G+TL208F+TL208E+TL208D+TL208C+TL208B+TL208A;
AIR_BAGS=CL208I+TL208I;
KIDSEATS=CL213+TL213;
FMVSS105=ML105B+ML105A+PL105B+PL105A+CL105B+CL105A+TL105B+TL105A;
FMVSS108=CL108+TL108;
FMVSS201=CL201+TL201;
FMVSS203=CL203+TL203;
FMVSS206=CL206+TL206;
FMVSS212=CL212+TL212;
FMVSS214=CL214B+CL214A+TL214A;
FMVSS216=CL216;
STDS8=FMVSS105+FMVSS108+FMVSS201+FMVSS203+FMVSS206+FMVSS212+FMVSS214+FMVSS216;
AB_DRV=CABDRV+TABDRV;
AB_RF = CABRF+ TABRF;
AB_KID=CABKID+TABKID;
RUN;

PROC PRINT DATA=CTP3;
  FORMAT SAVED VOL_SAVE STD_SAVE CL TL PL ML COMMA11.0;
  ID CY; VAR SAVED VOL_SAVE STD_SAVE CL TL PL ML;
  SUM SAVED VOL_SAVE STD_SAVE CL TL PL ML;
TITLE1 'OVERALL CAR OCCUPANT, LIGHT TRUCK OCCUPANT, PEDESTRIAN AND MOTORCYCLIST LIVES SAVED, 1975-
2002';
TITLE2 ' ';
TITLE3 'SAVED = OVERALL LIVES SAVED BY VEHICLE SAFETY IMPROVEMENTS (VOL_SAVE + STD_SAVE)';
TITLE4 'VOL_SAVE = OVERALL LIVES SAVED BY VOLUNTARY IMPROVEMENTS, BEFORE FMVSS EFFECTIVE DATE';
TITLE5 'STD_SAVE = OVERALL LIVES SAVED BY VEHICLES BUILT ON OR AFTER FMVSS EFFECTIVE DATE';
TITLE6 'CL = CAR OCCUPANT LIVES SAVED';
TITLE7 'TL = LIGHT TRUCK OCCUPANT LIVES SAVED';
TITLE8 'PL = PEDESTRIAN/NONOCCUPANT LIVES SAVED BY CAR AND LIGHT TRUCK BRAKING IMPROVEMENTS';
TITLE9 'ML = MOTORCYCLIST LIVES SAVED BY CAR AND LIGHT TRUCK BRAKING IMPROVEMENTS';
RUN;

PROC PRINT DATA=CTP3;
  FORMAT F_ACTUAL F_POTNTL PV_SAVE COMMA11.0 PCT_SAVE 6.2;
  ID CY; VAR F_ACTUAL F_POTNTL PV_SAVE PCT_SAVE;
  SUM F_ACTUAL F_POTNTL PV_SAVE;
TITLE1 'OVERALL LIVES SAVED AND NET EFFECTIVENESS OF SAFETY IMPROVEMENTS FOR PASSENGER VEHICLES
(CARS + LIGHT TRUCKS), 1975-2002';
TITLE2 ' ';
TITLE3 'F_ACTUAL = ACTUAL CAR + LIGHT TRUCK OCCUPANT FATALITIES';
TITLE4 'F_POTNTL = FATALITIES THAT WOULD HAVE OCCURRED WITHOUT ANY VEHICLE SAFETY IMPROVEMENTS';
TITLE5 'PV_SAVE = CAR + LIGHT TRUCK OCCUPANT LIVES SAVED BY VEHICLE SAFETY IMPROVEMENTS';
TITLE6 'PCT_SAVE = PERCENT OF WOULD-HAVE-BEEN FATALITIES SAVED BY SAFETY STANDARDS AND
TECHNOLOGIES';
RUN;

PROC PRINT DATA=CTP3;
  FORMAT BELTS AIR_BAGS KIDSEATS COMMA11.0;
  ID CY; VAR BELTS AIR_BAGS KIDSEATS;
  SUM BELTS AIR_BAGS KIDSEATS;
TITLE1 'LIVES SAVED IN CARS + LIGHT TRUCKS BY SAFETY BELTS, AIR BAGS AND CHILD SAFETY SEATS, 1975-
2002';
TITLE2 ' ';
TITLE3 'BELTS = LIVES SAVED BY SAFETY BELTS (ALL TYPES, ALL SEAT POSITIONS)';
TITLE4 'AIR_BAGS = LIVES SAVED BY FRONTAL AIR BAGS, DRIVERS + RIGHT-FRONT PASSENGERS';
TITLE5 'KIDSEATS = LIVES SAVED BY CHILD SAFETY SEATS (ALL TYPES, ALL SEAT POSITIONS, ALL AGES)';
RUN;

PROC PRINT DATA=CTP3;
  FORMAT FMVSS105 FMVSS108 FMVSS201 FMVSS203 FMVSS206 FMVSS212 FMVSS214 FMVSS216 STDS8 9.0;
```

```
  ID CY; VAR FMVSS105 FMVSS108 FMVSS201 FMVSS203 FMVSS206 FMVSS212 FMVSS214 FMVSS216 STDS8;
  SUM FMVSS105 FMVSS108 FMVSS201 FMVSS203 FMVSS206 FMVSS212 FMVSS214 FMVSS216 STDS8;
TITLE1 'LIVES SAVED BY THE OTHER SAFETY STANDARDS, 1975-2002';
TITLE2 ' ';
TITLE3 'FMVSS105 = DUAL MASTER CYLINDERS + FRONT DISC BRAKES (INCLUDES OCCUPANT + PEDESTRIAN LIVES
SAVED)';
TITLE4 'FMVSS108 = TRAILER CONSPICUITY TAPE (LIVES SAVED BY CARS & LIGHT TRUCKS NOT HITTING THE
TRAILERS)';
TITLE5 'FMVSS201 = VOLUNTARY INSTRUMENT PANEL IMPROVEMENTS    FMVSS203 = ENERGY-ABSORBING STEERING
ASSEMBLIES (INCLUDES FMVSS 204)';
TITLE6 'FMVSS206 = IMPROVED DOOR LOCKS                        FMVSS212 = ADHESIVE WINDSHIELD
BONDING';
TITLE7 'FMVSS214 = SIDE DOOR BEAMS IN CARS AND LIGHT TRUCKS, VOLUNTARY TTI(d) REDUCTIONS IN 2-DOOR
CARS';
TITLE8 'FMVSS216 = ROOF CRUSH STRENGTH FOR PASSENGER CARS';
TITLE9 'STDS8    = LIVES SAVED BY THESE EIGHT STANDARDS (I.E., EVERTHING EXCEPT BELTS, AIR BAGS AND
SAFETY SEATS)';
RUN;
```

Five pages of more detailed summary for air bags: (1) driver lives saved; (2) adult passenger lives saved in vehicles without switches; (3) estimated net fatality increase for child passengers in vehicles without switches; (4) actual adult passenger lives saved in pickup trucks with switches, and potential lives saved if the trucks did not have the switches (or if the air bags were always “on” for adults); (5) estimated actual net increase in child passenger fatalities in pickup trucks with switches, potential number of child fatalities if these trucks had air bags and no switches, and lives saved because the switches were turned “off.”

```
PROC PRINT DATA=CTP3;
  FORMAT AB_DRV CABDRV TABDRV COMMA11.0;
  ID CY; VAR AB_DRV CABDRV TABDRV;
  SUM AB_DRV CABDRV TABDRV;
TITLE1 'LIVES SAVED BY DRIVER AIR BAGS IN ALL CARS AND LIGHT TRUCKS, 1975-2002';
TITLE2 ' ';
TITLE3 'AB_DRV = LIVES SAVED BY DRIVER AIR BAGS IN CARS + LIGHT TRUCKS';
TITLE4 'CABDRV = LIVES SAVED BY DRIVER AIR BAGS IN CARS';
TITLE5 'TABDRV = LIVES SAVED BY DRIVER AIR BAGS IN LIGHT TRUCKS';
RUN;

PROC PRINT DATA=CTP3;
  FORMAT AB_RF CABRF TABRF COMMA11.0;
  ID CY; VAR AB_RF CABRF TABRF;
  SUM AB_RF CABRF TABRF;
TITLE1 'ADULT (AGE 13+) LIVES SAVED BY PASSENGER AIR BAGS IN CARS AND LIGHT TRUCKS WITHOUT ON-OFF
SWITCHES';
TITLE2 ' ';
TITLE3 'AB_RF = ADULT LIVES SAVED BY PASSENGER AIR BAGS IN CARS + LIGHT TRUCKS WITHOUT ON-OFF
SWITCHES';
TITLE4 'CABRF = ADULT LIVES SAVED BY PASSENGER AIR BAGS IN CARS';
TITLE5 'TABRF = ADULT LIVES SAVED BY PASSENGER AIR BAGS IN LIGHT TRUCKS WITHOUT ON-OFF SWITCHES';
RUN;

PROC PRINT DATA=CTP3;
  FORMAT AB_KID CABKID TABKID COMMA11.0;
  ID CY; VAR AB_KID CABKID TABKID;
  SUM AB_KID CABKID TABKID;
TITLE1 'CHILD (AGE 0-12) FATALITIES DUE TO AIR BAGS IN CARS AND LIGHT TRUCKS WITHOUT ON-OFF
SWITCHES';
TITLE2 ' ';
TITLE3 'AB_KID = CHILD FATALITIES DUE TO AIR BAGS IN CARS + LIGHT TRUCKS WITHOUT ON-OFF SWITCHES';
TITLE4 'CABKID = CHILD FATALITIES DUE TO AIR BAGS IN CARS';
TITLE5 'TABKID = CHILD FATALITIES DUE TO AIR BAGS IN LIGHT TRUCKS WITHOUT ON-OFF SWITCHES';
RUN;
```

```
PROC PRINT DATA=CTP3;
  FORMAT SW0 SW1 SW2 COMMA11.0;
  ID CY; VAR SW0 SW1 SW2;
  SUM SW0 SW1 SW2;
TITLE1 'ADULT (AGE 13+) LIVES SAVED BY PASSENGER AIR BAGS IN PICKUP TRUCKS WITH ON-OFF SWITCHES';
TITLE2 ' ';
TITLE3 'SW0 = ACTUAL ADULT LIVES SAVED BY AIR BAGS & SWITCHES LEFT ON';
TITLE4 'SW1 = THEORETICAL ADDITIONAL LIVES SAVED IF SWITCHES HAD NOT EXISTED';
TITLE5 'SW2 = LIVES LOST BECAUSE SWITCHES WERE TURNED OFF FOR ADULT PASSENGERS';
RUN;
PROC PRINT DATA=CTP3;
  FORMAT SWKID0 SWKID1 SWKID2 COMMA11.0;
  ID CY; VAR SWKID0 SWKID1 SWKID2;
  SUM SWKID0 SWKID1 SWKID2;
TITLE1 'CHILD (AGE 0-12) FATALITIES DUE TO AIR BAGS IN PICKUP TRUCKS WITH ON-OFF SWITCHES';
TITLE2 ' ';
TITLE3 'SWKID0 = ACTUAL ADDITIONAL CHILD PASSENGER FATALITIES DUE TO AIR BAGS & SWITCHES LEFT ON';
TITLE4 'SWKID1 = THEORETICAL ADDITIONAL FATALITIES IF SWITCHES HAD NOT EXISTED';
TITLE5 'SWKID2 = LIVES SAVED BECAUSE SWITCHES WERE TURNED OFF FOR CHILD PASSENGERS';
RUN;
```

The main model has been completed. However, subsets of the main databases are generated to describe the distribution of CY 1975-80 fatality cases on certain core variables. These subsets will be saved as *FARS7580*, *PED7580*, and *MC7580*. They will be used to set up the post-processor (lives saved in 1960-74).

```
/* ------------------------------------------------------------------------ */
/*  CREATES CY 75-80 OCCUPANT, NON-OCC & MOTORCYCLIST DATABASES NEEDED TO RUN  */
/*  OLDFARS1 AND OLDFARS2 (LIVES SAVED IN CY 1960-74)                        */
/* ------------------------------------------------------------------------ */

DATA FARS7580.FARS7580; SET CAR1 TRK1;
IF 1975 LE CY LE 1980;
IF EJECTION IN (1,2) THEN EJECT2=1; ELSE EJECT2=0;
VEHAGE=CY-MY;
KEEP AGE CRSH CY EJECT2 EJECTION IMPACT2 MY M_HARM ORIGWT REST3
  SEAT2 VEHAGE VE_FORMS VTYP WEIGHTFA;
RUN;

DATA PED7580.PED7580; SET PED1;
IF 1975 LE CY LE 1980;
VEHAGE=CY-MY;
KEEP CY MY VTYP ORIGWT VEHAGE WEIGHTFA;
RUN;

DATA MC7580.MC7580; SET MC1;
IF 1975 LE CY LE 1980;
VEHAGE=CY-OMY;
MY=OMY;
VTYP=OVTYP;
KEEP CY MY VTYP ORIGWT VEHAGE WEIGHTFA;
RUN;

/* ------------------------------------------------------------------ */
/*  AVERAGE COMPLIANCE WITH STDS, BY MODEL YEAR, TO SET UP OLDFA24    */
/* ------------------------------------------------------------------ */
```

Also needed for the post-processor are the percentage, by model year (1960-75), of cars with energy-absorbing columns, side door beams and adhesive bonding, and the percent of LTVs with energy-absorbing columns. For collisions of cars/LTVs with non-occupants or motorcyclists, we need the percentage, by model year of the car or LTV of post-standard vs. voluntary brake

improvements (this percentage depends on the proportion of striking vehicles that are cars vs. the proportion that are LTVs, in certain model years).

```
DATA OLDCAR; SET CAR2;
IF 1960 LE MY LE 1975;
IF SEAT2=11;
KEEP MY PS203 PV203 PS214A PV214A PS212 PV212 ORIGWT;
PROC SORT; BY MY;
PROC MEANS MEAN NOPRINT; BY MY; WEIGHT ORIGWT;
  VAR PS203 PV203 PS214A PV214A PS212 PV212;
  OUTPUT OUT=OLDCAR2 MEAN=PS203 PV203 PS214A PV214A PS212 PV212;
PROC PRINT DATA=OLDCAR2; ID MY; VAR PS203 PV203 PS214A PV214A PS212 PV212;
TITLE 'CARS';
RUN;

DATA OLDTRK; SET TRK2;
IF 1960 LE MY LE 1975;
IF SEAT2=11;
KEEP MY PV203 ORIGWT;
PROC SORT; BY MY;
PROC MEANS MEAN NOPRINT; BY MY; WEIGHT ORIGWT; VAR PV203;
  OUTPUT OUT=OLDTRK2 MEAN=PV203;
PROC PRINT DATA=OLDTRK2; ID MY; VAR PV203;
TITLE 'LIGHT TRUCKS';
RUN;

DATA OLDPED; SET PED2;
IF 1960 LE MY LE 1975;
KEEP MY PS105A PV105A PS105B PV105B ORIGWT;
PROC SORT; BY MY;
PROC MEANS MEAN NOPRINT; BY MY; WEIGHT ORIGWT;
  VAR PS105A PV105A PS105B PV105B;
  OUTPUT OUT=OLDPED2 MEAN=PS105A PV105A PS105B PV105B;
PROC PRINT DATA=OLDPED2; ID MY; VAR PS105A PV105A PS105B PV105B;
TITLE 'NON-OCCUPANTS HIT BY CARS OR LTVs, BY MODEL YEAR OF THE CAR OR LTV';
RUN;

DATA OLDMC; SET MC2;
IF 1960 LE OMY LE 1975;
KEEP OMY MS105A MV105A MS105B MV105B ORIGWT;
PROC SORT; BY OMY;
PROC MEANS MEAN NOPRINT; BY OMY; WEIGHT ORIGWT;
  VAR MS105A MV105A MS105B MV105B;
  OUTPUT OUT=OLDMC2 MEAN=MS105A MV105A MS105B MV105B;
PROC PRINT DATA=OLDMC2; ID OMY; VAR MS105A MV105A MS105B MV105B;
TITLE 'MOTORCYCLISTS HIT BY CARS OR LTVs, BY MODEL YEAR OF THE CAR OR LTV';
RUN;

/* ------------------------------------------------------------------ */
/*  AVERAGE COMPLIANCE WITH STDS, BY MY, TO FIND CHRONOLOGICAL ORDER  */
/* ------------------------------------------------------------------ */
```

Also computes the percent of cars and LTVs, by model year, equipped with the various safety technologies (except belts, child safety seats and conspicuity tape). This information is used to check that the models "remove" the technologies in the correct (reverse-chronological) order.

The first set of technologies is counted "per driver" (IF SEAT2=11), because they are installed at the driver's seat (e.g., energy-absorbing columns), or are vehicle-wide (e.g., brakes).

```
DATA ALLCAR1; SET CAR2;
IF 1960 LE MY LE 2002;
IF SEAT2=11;
KEEP MY PVNCAP PS216 PV216 PS105B PV105B PS203 PV203 PS214A PV214A
   PS105A PV105A PS206 PV206 PS212 PV212 ORIGWT;
PROC SORT; BY MY;
PROC MEANS MEAN NOPRINT; BY MY; WEIGHT ORIGWT;
```

```
  VAR PVNCAP PS216 PV216 PS105B PV105B PS203 PV203 PS214A PV214A
      PS105A PV105A PS206 PV206 PS212 PV212;
  OUTPUT OUT=ALLCAR1A
         MEAN=PVNCAP PS216 PV216 PS105B PV105B PS203 PV203 PS214A
              PV214A PS105A PV105A PS206 PV206 PS212 PV212;
RUN;
```

Air bags and automatic belts are counted "per front-seat occupant."

```
DATA ALLCAR2; SET CAR2;
IF 1960 LE MY LE 2002;
IF SEAT2 IN (11,13);
KEEP MY PS208I PV208I PS208H PV208H ORIGWT;
PROC SORT; BY MY;
PROC MEANS MEAN NOPRINT; BY MY; WEIGHT ORIGWT;
  VAR PS208I PV208I PS208H PV208H;
  OUTPUT OUT=ALLCAR2A MEAN=PS208I PV208I PS208H PV208H;
RUN;
```

Voluntary TTI(d) improvements are counted "per front-seat occupant of 2-door cars."

```
DATA ALLCAR3; SET CAR2;
IF 1960 LE MY LE 2002;
IF SEAT2 IN (11,13) AND BOD2 IN (1,2,3);
KEEP MY PV214B ORIGWT;
PROC SORT; BY MY;
PROC MEANS MEAN NOPRINT; BY MY; WEIGHT ORIGWT;
  VAR PV214B;
  OUTPUT OUT=ALLCAR3A MEAN=PV214B;
RUN;
```

Instrument panel improvements are counted "per RF passenger" because, in CAR2, PV201 can equal 1 only for RF passengers.

```
DATA ALLCAR4; SET CAR2;
IF 1960 LE MY LE 2002;
IF SEAT2=13;
KEEP MY PV201 ORIGWT;
PROC SORT; BY MY;
PROC MEANS MEAN NOPRINT; BY MY; WEIGHT ORIGWT;
  VAR PV201;
  OUTPUT OUT=ALLCAR4A MEAN=PV201;
RUN;

DATA ALLCAR5; MERGE ALLCAR1A ALLCAR2A ALLCAR3A ALLCAR4A; BY MY;
PROC PRINT DATA=ALLCAR5;
  FORMAT PS208I PV208I PV214B PS208H PV208H PVNCAP PS216 PV216 PS105B PV105B PS214A
         PV214A PV201 PS203 PV203 PS105A PV105A PS206 PV206 PS212 PV212 6.4;
  ID MY;
  VAR PS208I PV208I PV214B PS208H PV208H PVNCAP PS216 PV216 PS105B PV105B PS214A
      PV214A PV201 PS203 PV203 PS105A PV105A PS206 PV206 PS212 PV212;
TITLE 'CARS: PERCENT OF NEW VEHICLES WITH SAFETY TECHNOLOGY';
RUN;

DATA ALLTRK1; SET TRK2;
IF 1960 LE MY LE 2002;
IF SEAT2=11;
KEEP MY PS105B PV105B PS203 PV203 PS214A PV214A
   PS105A PV105A PS206 PV206 PS212 PV212 ORIGWT;
PROC SORT; BY MY;
PROC MEANS MEAN NOPRINT; BY MY; WEIGHT ORIGWT;
  VAR PS105B PV105B PS203 PV203 PS214A PV214A
      PS105A PV105A PS206 PV206 PS212 PV212;
  OUTPUT OUT=ALLTRK1A
```

```
         MEAN=PS105B PV105B PS203 PV203 PS214A
              PV214A PS105A PV105A PS206 PV206 PS212 PV212;
RUN;

DATA ALLTRK2; SET TRK2;
IF 1960 LE MY LE 2002;
IF SEAT2 IN (11,13);
KEEP MY PS208I PV208I ORIGWT;
PROC SORT; BY MY;
PROC MEANS MEAN NOPRINT; BY MY; WEIGHT ORIGWT;
  VAR PS208I PV208I;
  OUTPUT OUT=ALLTRK2A MEAN=PS208I PV208I;
RUN;

DATA ALLTRK4; SET TRK2;
IF 1960 LE MY LE 2002;
IF SEAT2=13;
KEEP MY PV201 ORIGWT;
PROC SORT; BY MY;
PROC MEANS MEAN NOPRINT; BY MY; WEIGHT ORIGWT;
  VAR PV201;
  OUTPUT OUT=ALLTRK4A MEAN=PV201;
RUN;

DATA ALLTRK5; MERGE ALLTRK1A ALLTRK2A ALLTRK4A; BY MY;
PROC PRINT DATA=ALLTRK5;
  FORMAT PS208I PV208I PS105B PV105B PS214A
      PV214A PV201 PS203 PV203 PS105A PV105A PS206 PV206 PS212 PV212 6.4;
  ID MY;
  VAR PS208I PV208I PS105B PV105B PS214A
      PV214A PV201 PS203 PV203 PS105A PV105A PS206 PV206 PS212 PV212;
TITLE 'LTVs: PERCENT OF NEW VEHICLES WITH SAFETY TECHNOLOGY';
RUN;
```

DESCRIPTION OF THE POSTPROCESSOR PROGRAM OLDFA24 (LIVES SAVED IN CY 1960-74)

```
OPTION NOCENTER NOFMTERR OBS=5000000 LS=153 PAGESIZE=47;
/*  PROGRAM NAME: OLDFA24.SAS              UPDATED: 04/14/2004 */
/*  LIVES SAVED BY FMVSS IN 1960-74                            */
```

Codes for impact location/crash type (CRSH):

```
PROC FORMAT; VALUE CRSH 1='FRONTAL' 2='SIDE IMPACT' 2.1='SIDE FIXED OBJ'
  2.2='SIDE MULTIVEH' 3='ROLLOVER (PRIMARY)' 4='REAR & OTHER' 9='UNKNOWN';
```

Codes for vehicle type:

```
PROC FORMAT; VALUE VTYP 1='PASSENGER CAR' 2='LIGHT TRUCK' 3='BIG TRUCK, BUS'
  4='MOTORCYCLE' 5='OTHER' 9='UNKNOWN';
PROC FORMAT; VALUE MY 1900-1954='PRE-1955' 1955-1959='1955-59' 1960-1961='1960-61';
```

Codes for streamlined seat position variable (SEAT2):

```
PROC FORMAT; VALUE NEWSEAT 11='DRIVER' 12='CENTER FRONT' 13='RIGHT FRONT' 18='OTHER FRONT'
  19='UNK FRONT' 21='OUTBOARD REAR' 22='CENTER REAR' 28='OTHER REAR'
  29='UNK REAR' 51='OTHER ENCLOSED' 52='UNENCLOSED' 99='UNK PASSENGER';
PROC FORMAT; VALUE NEWVTYP 1='CONVERTIBLE' 2='2-DOOR CAR' 4='4-DOOR CAR'
  6='STATION WAGON' 9='CAR, UNK STYLE'
  11='PICKUP TRUCK' 12='S U V' 13='VAN' 19='TRUCK, UNK STYLE';
```

Codes for streamlined restraint use variables (REST2 and REST3):

```
PROC FORMAT; VALUE NEWREST 0='UNRESTRAINED' 2='LAP BELT ONLY'
  3='LAP+SHOULDER BELT' 4='CHILD SAFETY SEAT' 7='2-PT AUTOMATIC BELT';
proc format; value vehage 25-99='ge 25';
RUN;
```

OLDFA24 begins by computing the ratio of certain fatality counts on FARS to counts in *Accident Facts* for CY 1975-80.[1] By applying these ratios to *Accident Facts* counts for any year before 1975, it estimates what the fatality count "would have been on FARS" if FARS had existed in that year. For example, *Accident Facts* counts of non-occupant fatalities total up to 60,100 for 1975-80. We do not know what vehicles struck the non-occupants: they could have been cars, LTVs, heavy trucks, or some other type. The 1975-80 FARS data suggest that 47,250 non-occupants were fatally injured in collisions by passenger cars or LTVs under conditions that qualify as "fatal motor-vehicle traffic crashes" as defined in FARS. This number, 47,250, is produced by another program, OLDFA41, that analyzes the 1975-80 data files produced by LS2004. Thus, the *Accident Facts* counts of non-occupant fatalities for any preceding year is multiplied by 47,250/60,100 to obtain an estimate of how many non-occupant fatalities in collisions with cars or LTVs would have been on FARS, if FARS had existed that year.

[1] For example, *Accident Facts 1978 Edition*, National Safety Council, Chicago, 1978, pp. 56 and 58.

```
/* ------------------------------------------------------------------------------ */
/*  1960-74 FATALITY COUNTS IMPUTED FROM ACCIDENT FACTS                           */
/*                                                                                */
/*  USING 1975-80 FARS AND ACCIDENT FACTS FATALITY COUNTS,                        */
/*  ADJUSTS THE 1960-74 ACCIDENT FACTS COUNTS (AFPED, AFCAR, AFTRK, AFMC)         */
/*  TO MATCH WHAT WOULD HAVE BEEN ON FARS (FARSPED, FARSCAR, FARSTRK, FARSMC)     */
/*                                                                                */
/*  FOR EXAMPLE:                                                                  */
/*  60100=ACC FACTS 1975-80 NONOCCS                                               */
/*  47250=FARS 75-80 NONOCCS STRUCK BY CARS OR LIGHT TRUCKS (OLDFA14, P. 3)       */
/*  FARSPED = 47250/60100 * AFPED IN EACH YEAR BEFORE 1975                        */
/*                                                                                */
/*  168100=ACC FACTS 1975-80 CAR OCCUPANT FATALITIES                              */
/*  35950=ACC FACTS 1975-80 TRUCK OCCUPANT FATALITIES                             */
/*                                                                                */
/*  ADDITIONAL ADJUSTMENT BEFORE 1965, BASED ON 1965                              */
/*  37900=ACC FACTS 65 TOTAL FATALITIES MINUS NONOCC + MCYCLE, ETC. IN EARLIER YEARS */
/*  31990.47 = FARSCAR FOR 65 (32600*164957/168100)                               */
/*   4527.41 = FARSTRK FOR 65 (4400*36991/35950)                                  */
/* ------------------------------------------------------------------------------ */
```

ACCFAC1 reads in the *Accident Facts* counts for total fatalities, non-occupants, car occupants, "truck" occupants and motorcyclists in each year, 1960-74. The FARS – *Accident Facts* fatality ratios for 1975-80 are:

- 47,250 FARS non-occupants in collisions with cars/LTVs to 60,100 *Accident Facts* non-occupants (any collision type).
- 11,787 FARS motorcyclists in collisions with cars/LTVs to 22,800 *Accident Facts* motorcyclists (any collision type).
- 164,957 FARS car occupant fatalities to 168,100 *Accident Facts* car occupant fatalities.
- 36,991 FARS LTV occupant fatalities to 35,950 *Accident Facts* "truck" occupant fatalities.

These ratios are used to estimate the numbers of fatalities that would have been on FARS, if it had existed, in 1960-74: FARSPED, FARSMC, FARSCAR, FARSTRK.

An additional calculation (as shown below) is needed for 1960-64, when *Accident Facts* did not separately indicate car and truck occupant fatalities, only total, non-occupant and motorcyclist fatalities.

```
DATA ACCFAC1;
INPUT CY 1-4 AFTOT 6-10 AFPED 12-16 AFCAR 18-22 AFTRK 24-27 AFMC 29-32;
FARSPED=AFPED*47250/60100;                                  /* 47250 FROM OLDFA14, P. 3 */
FARSMC=AFMC*11787/22800;                                    /* 11787 FROM OLDFA14, P. 4 */
IF AFCAR=. THEN FARSCAR=(AFTOT-(AFPED+AFMC))*(31990.47/37900);
  ELSE FARSCAR=AFCAR*164957/168100;                         /* 164957 FROM OLDFA14, P. 5 */
IF AFTRK=. THEN FARSTRK=(AFTOT-(AFPED+AFMC))*( 4527.41/37900);
  ELSE FARSTRK=AFTRK*36991/35950;                           /* 36991 FROM OLDFA14, P. 6 */
CARDS;
1960 38200  8200     .    .  750
1961 38000  8150     .    .  700
1962 40900  8400     .    .  800
1963 43600  8800     .    .  900
1964 47700  9650     .    . 1100
1965 49000  9500 32600 4400 1600
1966 53000 10050 35000 4650 2150
1967 53100 10100 35200 4650 2000
1968 55200 10600 36400 5150 1900
1969 56400 10600 37100 5550 1950
```

```
1970 54800 11200 34700 5350 2300
1971 54700 11450 34100 5300 2200
1972 56600 11800 35100 5500 2700
1973 55800 11650 33500 5700 3100
1974 46200  9700 26600 4900 3200
RUN;

PROC PRINT; ID CY;
TITLE 'FATALITIES REPORTED IN ACCIDENT FACTS AND IMPUTED IN FARS, BASED ON 1975-80 RATIOS';
RUN;
```

Here are the resulting estimates of FARSPED, FARSMC, FARSCAR and FARSTRK:

CY	FARSPED	FARSMC	FARSCAR	FARSTRK
1960	6446.76	387.73	24689.21	3494.11
1961	6407.45	361.88	24604.81	3482.16
1962	6603.99	413.58	26757.20	3786.78
1963	6918.47	465.28	28614.17	4049.58
1964	7586.73	568.67	31188.60	4413.93
1965	7468.80	827.16	31990.47	4527.41
1966	7901.21	1111.49	34345.60	4784.65
1967	7940.52	1033.95	34541.86	4784.65
1968	8333.61	982.25	35719.42	5299.13
1969	8333.61	1008.10	36406.33	5710.71
1970	8805.32	1189.04	34051.21	5504.92
1971	9001.87	1137.34	33462.43	5453.47
1972	9277.04	1395.83	34443.73	5659.26
1973	9159.11	1602.62	32873.64	5865.05
1974	7626.04	1654.32	26102.65	5041.89

```
/* ------------------------------------------------------------------ */
/*  VEHICLE AGE DISTRIBUTIONS IN 1975-80 FARS FATALITIES:             */
/*  CARS/LIGHT TRUCKS HITTING PEDS, CAR OCCUPANTS, LIGHT TRUCK OCCS   */
/*                                                                    */
/*  TYPE IN FIRST COLUMNS ON PP. 3-6 OF OLDFA14                       */
/* ------------------------------------------------------------------ */
```

Working with the files *FARS7580*, *PED7580*, and *MC7580* generated by LS2004, OLDFA14 computes the vehicle-age distribution, in 1975-80, of the cars/LTVs that hit non-occupants, the car occupant fatalities, the LTV occupant fatalities, and the cars/LTVs that hit motorcyclists.

```
DATA VEHAGE1; INPUT VEHAGE 4-5 NPED 10-17 NCAR 22-29 NTRK NMC;
CASEFLAG=1;
CARDS;
   -1    162.4817    605.2072    109.1351    21.3214
    0     3364.35    11344.2     3351.701   796.6358
    1    4819.269    15132.48    5172.744  1213.928
    2    4603.945    13773.37    4285.246  1119.965
    3    4382.934    13421.52    3597.582   977.4574
    4    3983.189    13338.52    3032.132   945.1746
    5    3867.286    13428.7     2596.071   964.3163
    6    4034.862    14013.89    2346.24    985.7485
    7    3787.245    13593.19    2068.892   936.6506
    8    3224.628    12302.93    1682.43    860.7186
    9    2942.550    10758.34    1374.067   670.5461
```

```
   10    2298.511    9071.043    1304.867   618.9576
   11    1829.233    7177.197    1109.991   493.7239
   12    1298.031    5443.185    924.8238   340.0405
   13    876.5308    4058.674    768.6906   291.7421
   14    578.49      2736.983    609.642    157.1982
   15    385.4057    1688.982    442.6576   100.5024
   16    212.7371    1010.59     360.1974    78.11997
   17    138.6325    587.4548    287.0335    49.64865
   18    97.32384    348.0791    247.7068    29.4394
   19    70.10814    220.0954    185.4293    20.31554
   20    64.19948    226.6397    175.3913    21.4539
   21    51.34826    155.1664    139.663     11.14231
   22    33.84781    129.4678    139.7618    10.18185
   23    34.0774     102.6976    136.4589    13.26287
   24    30.53487    66.08272    113.1879     9.18104
ge 25    78.29803    222.098     429.6281    50.01732
RUN;
```

The above are actual (weighted) fatality counts. This code transforms them to percentages of the total:

```
PROC MEANS SUM NOPRINT DATA=VEHAGE1; VAR NPED NCAR NTRK NMC;
  OUTPUT OUT=VEHAGE2 SUM=TOTPED TOTCAR TOTTRK TOTMC;
DATA VEHAGE3; SET VEHAGE2; CASEFLAG=1;
DATA VEHAGE4; MERGE VEHAGE1 VEHAGE3; BY CASEFLAG;
PCTPED=NPED/TOTPED;
PCTCAR=NCAR/TOTCAR;
PCTTRK=NTRK/TOTTRK;
PCTMC =NMC /TOTMC;
KEEP VEHAGE PCTPED PCTCAR PCTTRK PCTMC;
```

First is the analysis of the effect of car/LTV brake improvements on non-occupant fatalities. To perform this analysis, we need to know, in each CY, how many vehicles of each MY hit non-occupants. Based on the MY, we know the probability they had dual master cylinders and/or front disc brakes.

```
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
/*  ANALYZES EFFECT OF BRAKE IMPROVEMENTS ON NONOCCUPANT FATALITIES   */
/*                                                                    */
/*  FIRST STEP: CREATE FILE WITH ALL POSSIBLE CY-MY COMBINATIONS      */
/*  WITH ORIGWT INDICATING THE NUMBER OF PEDESTRIAN FATALITIES        */
/*  FOR THAT COMBINATION (MY=MODEL YEAR OF THE VEH THAT HIT THE PED)  */
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
```

The file ACCFAC1 has one record for each CY, 1960-74, with FARSPED showing the total number of non-occupant fatalities in collisions with a car or LTV. This data step creates another file, PED5, that is a matrix with CY running from 1960 to 1974 and VEHAGE (vehicle age) running from –1, 0, 1, 2, … , 24, 25+. So far, it just has FARSPED, the CY grand total, on each record.

```
DATA PED5(KEEP=CY FARSPED VEHAGE);
SET ACCFAC1;
DO VEHAGE = -1 TO 25;
  OUTPUT;
END;
RUN;
PROC SORT DATA=PED5; BY VEHAGE;
```

To create PED6, we merge onto PED5 the proportion of the non-occupant fatalities (PCTPED) at each value of VEHAGE. ORIGWT = PCTPED * FARSPED is the number of fatalities, in that CY, at that VEHAGE. Because MY = CY – VEHAGE, PED6 is also a matrix of non-occupant fatalities by CY and MY (of the striking car/LTV).

PED6 looks like this:

CY	MY	ORIGWT
1960	≤ 1935	10.683
1960	1936	4.166
1960	1937	4.649
…		
1960	1959	657.537
1960	1960	459.029
1960	1961	22.169
1961	≤ 1936	10.618
1961	1937	4.141
…		
1961	1961	456.230
1961	1962	22.034
…		
…		
1974	≤ 1949	12.637
1974	1950	4.928
…		
1974	1973	777.818
1974	1974	542.998
1974	1975	26.224

```
DATA PED6; MERGE PED5 VEHAGE4; BY VEHAGE;
ORIGWT=PCTPED*FARSPED;
WEIGHTFA=ORIGWT;
MY=CY-VEHAGE;
KEEP CY MY ORIGWT WEIGHTFA;
PROC SORT DATA=PED6; BY CY MY;
RUN;

/* ------------------------------------------------------------- */
/*  REPEATS THE NONOCCUPANT ANALYSIS OF LS2004.SAS               */
/* ------------------------------------------------------------- */
```

The main analysis sections in the post-processor OLDFA24 are similar to the corresponding sections of the main processor LS2004. The principal difference is that LS2004 worked through the individual FARS cases, one case at a time. OLDFA24 works on cells rather than cases, one cell at a time. In the post-processor for non-occupant fatalities, two safety technologies, dual master cylinders (105A) and front disc brakes (105B) saved non-occupant lives because they enabled car/LTV drivers to avoid hitting the non-occupants. The model operates on the file PED6 that, as shown above, has one cell for each CY, MY combination. For example, the cell with CY = 1974 and MY = 1973 originally comprises 777.818 fatalities (ORIGWT). The model assumes that 86

percent of MY 1973 cars are equipped with front disc brakes and 100 percent with dual master cylinders. Disc brakes reduce pedestrian crashes by 0.17 percent, dual master cylinders by 0.7 percent. Thus, "removing" the disc brakes from the MY1973 cars will increase fatalities in that cell to 777.818 / (1 – (.86x.0017)) = 778.957 and removing the dual master cylinders will further increase them to 778.957 / (1 – .007) = 784.448 (the final WEIGHTFA). In this cell, braking technologies saved 784.448 – 777.818 = 6.63 lives.

For more details on the computation methods, see the notes on the corresponding sections of LS2004. In general, the notes on this program will be limited to the spots where it differs from LS2004.

```
DATA PED7; SET PED6;
/* IMPLEMENTATION OF FRONT DISC BRAKES IN THE VEHICLES THAT HIT THESE PEDESTRIANS */
  IF MY LE 1964 THEN DO; PS105B=0; PV105B=0; END;
    ELSE IF MY=1965 THEN DO; PS105B=0; PV105B=.02; END;
    ELSE IF MY=1966 THEN DO; PS105B=0; PV105B=.03; END;
    ELSE IF MY=1967 THEN DO; PS105B=0; PV105B=.06; END;
    ELSE IF MY=1968 THEN DO; PS105B=0; PV105B=.13; END;
    ELSE IF MY=1969 THEN DO; PS105B=0; PV105B=.28; END;
    ELSE IF MY=1970 THEN DO; PS105B=0; PV105B=.41; END;
    ELSE IF MY=1971 THEN DO; PS105B=0; PV105B=.63; END;
    ELSE IF MY=1972 THEN DO; PS105B=0; PV105B=.74; END;
    ELSE IF MY=1973 THEN DO; PS105B=0; PV105B=.86; END;
    ELSE IF MY=1974 THEN DO; PS105B=0; PV105B=.84; END;
    ELSE IF MY=1975 THEN DO; PS105B=0; PV105B=.93; END;
/* IMPLEMENTATION OF DUAL MASTER CYLINDERS IN THE VEHICLES THAT HIT THESE PEDESTRIANS */
IF MY LE 1961 THEN DO; PS105A=0; PV105A=0; END;
    ELSE IF MY IN (1962,1963) THEN DO; PS105A=0; PV105A=.09; END;
    ELSE IF MY IN (1964,1965) THEN DO; PS105A=0; PV105A=.07; END;
    ELSE IF MY=1966 THEN DO; PS105A=0; PV105A=.54; END;
    ELSE IF MY=1967 THEN DO; PS105A=0; PV105A=1; END;
    ELSE IF MY=1968 AND CY=1967 THEN DO; PS105A=0; PV105A=1; END;
```

In MY 1968-75, after January 1, 1968, the mix of post-standard and voluntary installations depends on the mix of cars and LTVs hitting non-occupants, because FMVSS 105 took effect on cars on January 1, 1968 but on LTVs not until September 1, 1983. (But all vehicles had dual master cylinders.) LS2004 prints these percentages on a page titled, "non-occupants hit by cars or LTVs, by model year of the car or LTV."

```
    ELSE IF MY=1968 THEN DO; PS105A=.42; PV105A=.58; END;
    ELSE IF MY=1969 THEN DO; PS105A=.81; PV105A=.19; END;
    ELSE IF MY=1970 THEN DO; PS105A=.82; PV105A=.18; END;
    ELSE IF MY=1971 THEN DO; PS105A=.81; PV105A=.19; END;
    ELSE IF MY=1972 THEN DO; PS105A=.80; PV105A=.20; END;
    ELSE IF MY=1973 THEN DO; PS105A=.78; PV105A=.22; END;
    ELSE IF MY=1974 THEN DO; PS105A=.74; PV105A=.26; END;
    ELSE IF MY=1975 THEN DO; PS105A=.76; PV105A=.24; END;
/* PEDESTRIAN LIVES SAVED BY FRONT DISC BRAKES */
  OLDWTFA=WEIGHTFA;
  IF PS105B GT 0 OR PV105B GT 0 THEN DO;
    E=.0017;
    P=PS105B+PV105B;
    S=OLDWTFA*E*P / (1 - E*P);
    PLS105B=S*PS105B/P;
    PLV105B=S*PV105B/P;
    WEIGHTFA=OLDWTFA+PLS105B+PLV105B; END;
  ELSE DO; PLS105B=0; PLV105B=0; END;
/* PEDESTRIAN LIVES SAVED BY DUAL MASTER CYLINDERS */
  OLDWTFA=WEIGHTFA;
```

```
  IF PS105A GT 0 OR PV105A GT 0 THEN DO;
    E=.007;
    P=PS105A+PV105A;
    S=OLDWTFA*E*P / (1 - E*P);
    PLS105A=S*PS105A/P;
    PLV105A=S*PV105A/P;
    WEIGHTFA=OLDWTFA+PLS105A+PLV105A; END;
  ELSE DO; PLS105A=0; PLV105A=0; END;
  PLS=PLS105A+PLS105B; PLV=PLV105A+PLV105B;
  PL105A=PLS105A+PLV105A; PL105B=PLS105B+PLV105B; PL=PLS+PLV;
RUN;
```

Adds up and prints out the totals for each calendar year, and the sum for all years, 1960-74.

```
PROC MEANS SUM NOPRINT DATA=PED7; BY CY;
  VAR ORIGWT WEIGHTFA PLV105B PLS105B PL105B PLV105A PLS105A PL105A PLV PLS PL;
  OUTPUT OUT=PED8
    SUM=P_ORIGWT P_WTFA PLV105B PLS105B PL105B PLV105A PLS105A PL105A PLV PLS PL;
PROC PRINT DATA=PED8;
  FORMAT P_ORIGWT P_WTFA PLV105B PLS105B PL105B PLV105A PLS105A PL105A PLV PLS PL 9.0;
  ID CY; VAR P_ORIGWT P_WTFA PLV105B PLS105B PL105B PLV105A PLS105A PL105A PLV PLS PL;
  SUM P_ORIGWT P_WTFA PLV105B PLS105B PL105B PLV105A PLS105A PL105A PLV PLS PL;
TITLE1 'PEDESTRIANS SAVED BY CAR/LIGHT TRUCK DISC BRAKES AND DUAL MASTER CYLINDERS, 1960-74';
TITLE2 ' ';
TITLE3 '...105B = FRONT DISC BRAKES (MEDIAN INSTALLATION YEAR 1971, FMVSS EFFECTIVE 1/1/76 OR
9/1/83)';
TITLE4 '...105A = DUAL MASTER CYLINDERS (MEDIAN INSTALLATION YEAR LATE 1966, FMVSS EFFECTIVE 1/1/68
OR 9/1/83)';
TITLE5 '...V = VOLUNTARY INSTALLATIONS, BEFORE EFFECTIVE DATE';
TITLE6 '...S = STANDARD INSTALLATIONS, AFTER EFFECTIVE DATE';
TITLE7 'P_ORIGWT = ACTUAL PED/BIKE/NONMOTORIST FATALITIES';
TITLE8 'P_WTFA = FATALITIES THAT WOULD HAVE OCCURRED WITHOUT THESE SAFETY IMPROVEMENTS';
TITLE9 'PL = OVERALL PED/BIKE/NONMOTORIST LIVES SAVED BY BRAKE IMPROVEMENTS IN CARS/LIGHT TRUCKS';
RUN;
```

The analysis of the effect of car/LTV brake improvements on motorcyclist fatalities is quite similar to the non-occupant analysis.

```
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
/*  ANALYZES EFFECT OF BRAKE IMPROVEMENTS ON MOTORCYCLIST FATALITIES  */
/*                                                                    */
/*  FIRST STEP: CREATE FILE WITH ALL POSSIBLE CY-MY COMBINATIONS      */
/*  WITH ORIGWT INDICATING THE NUMBER OF MOTORCYCLIST FATALITIES      */
/*  FOR THAT COMBINATION (MY=MODEL YEAR OF THE VEH THAT HIT THE MC)   */
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */

DATA MC5(KEEP=CY FARSMC VEHAGE);
SET ACCFAC1;
DO VEHAGE = -1 TO 25;
  OUTPUT;
END;
RUN;
PROC SORT DATA=MC5; BY VEHAGE;
DATA MC6; MERGE MC5 VEHAGE4; BY VEHAGE;
ORIGWT=PCTMC*FARSMC;
WEIGHTFA=ORIGWT;
MY=CY-VEHAGE;
KEEP CY MY ORIGWT WEIGHTFA;
PROC SORT DATA=MC6; BY CY MY;
RUN;

/* ------------------------------------------------------------------ */
/*  REPEATS THE MOTORCYCLIST ANALYSIS OF LS2004.SAS                   */
```

```
/* ------------------------------------------------------------ */

DATA MC7; SET MC6;
/* IMPLEMENTATION OF FRONT DISC BRAKES IN THE VEHICLES THAT HIT THESE MOTORCYCLISTS */
IF MY LE 1964 THEN DO; MS105B=0; MV105B=0; END;
    ELSE IF MY=1965 THEN DO; MS105B=0; MV105B=.02; END;
    ELSE IF MY=1966 THEN DO; MS105B=0; MV105B=.03; END;
    ELSE IF MY=1967 THEN DO; MS105B=0; MV105B=.06; END;
    ELSE IF MY=1968 THEN DO; MS105B=0; MV105B=.13; END;
    ELSE IF MY=1969 THEN DO; MS105B=0; MV105B=.28; END;
    ELSE IF MY=1970 THEN DO; MS105B=0; MV105B=.41; END;
    ELSE IF MY=1971 THEN DO; MS105B=0; MV105B=.63; END;
    ELSE IF MY=1972 THEN DO; MS105B=0; MV105B=.74; END;
    ELSE IF MY=1973 THEN DO; MS105B=0; MV105B=.86; END;
    ELSE IF MY=1974 THEN DO; MS105B=0; MV105B=.84; END;
    ELSE IF MY=1975 THEN DO; MS105B=0; MV105B=.93; END;
/* IMPLEMENTATION OF DUAL MASTER CYLINDERS IN THE VEHICLES THAT HIT THESE MOTORCYCLISTS */
  IF MY LE 1961 THEN DO; MS105A=0; MV105A=0; END;
    ELSE IF MY IN (1962,1963) THEN DO; MS105A=0; MV105A=.09; END;
    ELSE IF MY IN (1964,1965) THEN DO; MS105A=0; MV105A=.07; END;
    ELSE IF MY=1966 THEN DO; MS105A=0; MV105A=.54; END;
    ELSE IF MY=1967 THEN DO; MS105A=0; MV105A=1; END;
    ELSE IF MY=1968 AND CY=1967 THEN DO; MS105A=0; MV105A=1; END;
```

In MY 1968-75, after January 1, 1968, the mix of post-standard and voluntary installations depends on the mix of cars and LTVs hitting non-occupants, because FMVSS 105 took effect on cars on January 1, 1968 but on LTVs not until September 1, 1983. (But all vehicles had dual master cylinders.) LS2004 prints these percentages on a page titled, “motorcyclists hit by cars or LTVs, by model year of the car or LTV.” These percentages are slightly different for motorcyclists and non-occupants, because motorcycles have proportionately more collisions with LTVs and fewer with cars.

```
    ELSE IF MY=1968 THEN DO; MS105A=.40; MV105A=.60; END;
    ELSE IF MY=1969 THEN DO; MS105A=.74; MV105A=.26; END;
    ELSE IF MY=1970 THEN DO; MS105A=.76; MV105A=.24; END;
    ELSE IF MY=1971 THEN DO; MS105A=.72; MV105A=.28; END;
    ELSE IF MY=1972 THEN DO; MS105A=.72; MV105A=.28; END;
    ELSE IF MY=1973 THEN DO; MS105A=.72; MV105A=.28; END;
    ELSE IF MY=1974 THEN DO; MS105A=.68; MV105A=.32; END;
    ELSE IF MY=1975 THEN DO; MS105A=.69; MV105A=.31; END;
/* MOTORCYCLIST LIVES SAVED BY FRONT DISC BRAKES */
  OLDWTFA=WEIGHTFA;
  IF MS105B GT 0 OR MV105B GT 0 THEN DO;
    E=.0017;
    P=MS105B+MV105B;
    S=OLDWTFA*E*P / (1 - E*P);
    MLS105B=S*MS105B/P;
    MLV105B=S*MV105B/P;
    WEIGHTFA=OLDWTFA+MLS105B+MLV105B; END;
  ELSE DO; MLS105B=0; MLV105B=0; END;
/* MOTORCYCLIST LIVES SAVED BY DUAL MASTER CYLINDERS */
  OLDWTFA=WEIGHTFA;
  IF MS105A GT 0 OR MV105A GT 0 THEN DO;
    E=.007;
    P=MS105A+MV105A;
    S=OLDWTFA*E*P / (1 - E*P);
    MLS105A=S*MS105A/P;
    MLV105A=S*MV105A/P;
    WEIGHTFA=OLDWTFA+MLS105A+MLV105A; END;
  ELSE DO; MLS105A=0; MLV105A=0; END;
  MLS=MLS105A+MLS105B; MLV=MLV105A+MLV105B;
  ML105A=MLS105A+MLV105A; ML105B=MLS105B+MLV105B; ML=MLS+MLV;
```

```
RUN;

PROC MEANS SUM NOPRINT DATA=MC7; BY CY;
  VAR ORIGWT WEIGHTFA MLV105B MLS105B ML105B MLV105A MLS105A ML105A MLV MLS ML;
  OUTPUT OUT=MC8
    SUM=M_ORIGWT M_WTFA MLV105B MLS105B ML105B MLV105A MLS105A ML105A MLV MLS ML;
PROC PRINT DATA=MC8;
  FORMAT M_ORIGWT M_WTFA MLV105B MLS105B ML105B MLV105A MLS105A ML105A MLV MLS ML 9.0;
  ID CY; VAR M_ORIGWT M_WTFA MLV105B MLS105B ML105B MLV105A MLS105A ML105A MLV MLS ML;
  SUM M_ORIGWT M_WTFA MLV105B MLS105B ML105B MLV105A MLS105A ML105A MLV MLS ML;
TITLE1 'MOTORCYCLISTS SAVED BY CAR/LIGHT TRUCK DISC BRAKES AND DUAL MASTER CYLINDERS, 1960-74';
TITLE2 ' ';
TITLE3 '...105B = FRONT DISC BRAKES (MEDIAN INSTALLATION YEAR 1971, FMVSS EFFECTIVE 1/1/76 OR
9/1/83)';
TITLE4 '...105A = DUAL MASTER CYLINDERS (MEDIAN INSTALLATION YEAR LATE 1966, FMVSS EFFECTIVE 1/1/68
OR 9/1/83)';
TITLE5 '...V = VOLUNTARY INSTALLATIONS, BEFORE EFFECTIVE DATE';
TITLE6 '...S = STANDARD INSTALLATIONS, AFTER EFFECTIVE DATE';
TITLE7 'M_ORIGWT = ACTUAL MOTORCYCLIST FATALITIES';
TITLE8 'M_WTFA = FATALITIES THAT WOULD HAVE OCCURRED WITHOUT THESE SAFETY IMPROVEMENTS';
TITLE9 'ML = OVERALL MOTORCYCLIST LIVES SAVED BY BRAKE IMPROVEMENTS IN CARS/LIGHT TRUCKS';
RUN;


/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
/*  THE ANALYSIS OF PASSENGER CAR OCCUPANTS BEGINS HERE               */
/*                                                                    */
/*  CREATES A FILE WITH ALL POSSIBLE COMBINATIONS OF                  */
/*  CY, MY, CRASH MODE, OCC AGE GP, SEAT POSITION, RESTRAINT USE      */
/*  ORIGWT IS THE NUMBER OF OCC FATALITIES FOR EACH COMBINATION       */
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
```

The basic approach for car occupant fatalities resembles the analysis of non-occupants: first create a matrix of cells showing the distribution of fatalities by CY, MY and other factors, then analyze the matrix one cell at a time, estimating the fatality increase as the safety technologies are "removed" one by one. The difference is that a more complex matrix is needed here. In order to find out what technologies apply and how effective they are, we also need to know the impact location/crash type, and the occupant's age group, seat position, and restraint use. We will need a joint distribution of all these variables.

```
/* ------------------------------------------------------------------ */
/*  FIRST STEP: ALL CY-MY COMBINATIONS                                */
/*  BASED ON VEHICLE AGE DISTRIBUTION IN 1975-80 FARS                 */
/* ------------------------------------------------------------------ */
```

The initial matrix of fatalities by CY and MY (CAR6) is generated by the same code as used for non-occupants and motorcyclists.

```
DATA CAR5(KEEP=CY FARSCAR VEHAGE);
SET ACCFAC1;
DO VEHAGE = -1 TO 25;
  OUTPUT;
END;
RUN;
PROC SORT DATA=CAR5; BY VEHAGE;
DATA CAR6; MERGE CAR5 VEHAGE4; BY VEHAGE;
ORIGWT=PCTCAR*FARSCAR;
MY=CY-VEHAGE;
KEEP CY MY ORIGWT;
PROC SORT DATA=CAR6; BY CY MY;
```

```
RUN;

/* ---------------------------------------------------------------- */
/*  ALL PERMITTED COMBINATIONS OF CRASH MODE, AGE GROUP, SEAT POS   */
/*  AGE GROUPS ARE INFANT, TODDLER 1-4, ALL OTHERS 5 AND OLDER      */
/*  WEIGHT FACTORS BASED ON DISTRIBUTIONS IN 1975-80 FARS           */
/* ---------------------------------------------------------------- */
```

CAR7 is a matrix distributing fatalities not only by CY and MY but also by impact location/crash type (1 = frontal, 2.1 = side, single-vehicle, 2.2 = side, multivehicle, 3 = rollover, 4 = rear/other), seat position (see the NEWSEAT format at the beginning of the program) and occupant age group (0 = infant, 1 = toddler age 1-4, 5 = all other occupants, age 5+). The model assumes (for simplicity) that the crash mode is independent from the seat position and occupant age. Of course, seat position is not independent from occupant age (e.g., there are no infants or toddlers driving cars), and a joint distribution is needed for those two parameters. All distributions are based on 1975-80 FARS data, specifically the analysis by OLDFA14 of the file *FARS7580* generated by LS2004.

```
DATA CAR7(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP);
SET CAR6;
```

There were 120,401.5 weighted cases in the file analyzed by OLDFA14.
Thus, CRASHFA * ASFA / X is the proportion of cases for each crash mode-seat position-occupant age combination.

```
X=120401.5*120401.5;                                          /* FROM OLDFA14, P. 7 */
OLDWT=ORIGWT;
DO ICRSH=1 TO 5;
DO IAGESEAT=1 TO 25;
IF ICRSH=1 THEN DO; CRSH=1; CRSHFA=61393.68; END;             /* FROM OLDFA14, P. 7 */
  ELSE IF ICRSH=2 THEN DO; CRSH=2.1; CRSHFA=12942.7; END;
  ELSE IF ICRSH=3 THEN DO; CRSH=2.2; CRSHFA=22710.49; END;
  ELSE IF ICRSH=4 THEN DO; CRSH=3;   CRSHFA=18427.09; END;
  ELSE IF ICRSH=5 THEN DO; CRSH=4;   CRSHFA=4927.502; END;
IF IAGESEAT=1 THEN DO; SEAT2=11; AGEGP=5; ASFA=76173; END;    /* FROM OLDFA14, P. 7 */
  ELSE IF IAGESEAT= 2 THEN DO; SEAT2=12; AGEGP=0; ASFA=230.42; END;
  ELSE IF IAGESEAT= 3 THEN DO; SEAT2=12; AGEGP=1; ASFA=451.80; END;
  ELSE IF IAGESEAT= 4 THEN DO; SEAT2=12; AGEGP=5; ASFA=2458.9; END;
  ELSE IF IAGESEAT= 5 THEN DO; SEAT2=13; AGEGP=0; ASFA=302.37; END;
  ELSE IF IAGESEAT= 6 THEN DO; SEAT2=13; AGEGP=1; ASFA=622.66; END;
  ELSE IF IAGESEAT= 7 THEN DO; SEAT2=13; AGEGP=5; ASFA= 29280; END;
  ELSE IF IAGESEAT= 8 THEN DO; SEAT2=18; AGEGP=0; ASFA=33.569; END;
  ELSE IF IAGESEAT= 9 THEN DO; SEAT2=18; AGEGP=1; ASFA=39.501; END;
  ELSE IF IAGESEAT=10 THEN DO; SEAT2=18; AGEGP=5; ASFA=42.877; END;
  ELSE IF IAGESEAT=11 THEN DO; SEAT2=21; AGEGP=0; ASFA=85.037; END;
  ELSE IF IAGESEAT=12 THEN DO; SEAT2=21; AGEGP=1; ASFA=519.94; END;
  ELSE IF IAGESEAT=13 THEN DO; SEAT2=21; AGEGP=5; ASFA=7661.6; END;
  ELSE IF IAGESEAT=14 THEN DO; SEAT2=22; AGEGP=0; ASFA=63.575; END;
  ELSE IF IAGESEAT=15 THEN DO; SEAT2=22; AGEGP=1; ASFA=218.39; END;
  ELSE IF IAGESEAT=16 THEN DO; SEAT2=22; AGEGP=5; ASFA=1625.6; END;
  ELSE IF IAGESEAT=17 THEN DO; SEAT2=28; AGEGP=0; ASFA=4.8798; END;
  ELSE IF IAGESEAT=18 THEN DO; SEAT2=28; AGEGP=1; ASFA=13.574; END;
  ELSE IF IAGESEAT=19 THEN DO; SEAT2=28; AGEGP=5; ASFA=84.192; END;
  ELSE IF IAGESEAT=20 THEN DO; SEAT2=51; AGEGP=0; ASFA=5.8478; END;
  ELSE IF IAGESEAT=21 THEN DO; SEAT2=51; AGEGP=1; ASFA= 37.321; END;
  ELSE IF IAGESEAT=22 THEN DO; SEAT2=51; AGEGP=5; ASFA= 204.76; END;
  ELSE IF IAGESEAT=23 THEN DO; SEAT2=52; AGEGP=0; ASFA=  1.1127; END;
  ELSE IF IAGESEAT=24 THEN DO; SEAT2=52; AGEGP=1; ASFA=2.0335; END;
  ELSE IF IAGESEAT=25 THEN DO; SEAT2=52; AGEGP=5; ASFA=238.91; END;
ORIGWT=OLDWT*CRSHFA*ASFA/X;
```

```
OUTPUT;
END;
END;
RUN;
```

```
/* ---------------------------------------------------------------- */
/*  ALL PERMITTED CONFIGURATIONS OF RESTRAINT USE                   */
/*                                                                  */
/*  SEPARATE ANALYSES BY SEAT POSITION, MODEL YEAR & AGE GROUP      */
/*  DEPENDING ON WHAT TYPES AND HOW MANY SYSTEMS ARE AVAILABLE      */
/*  USE RATES BASED ON 1975-80 AVGS, EXCEPT WHERE 1975 IS HIGHER    */
/*  FIRST MODERN SAFETY SEATS: CY 1967 (TODDLER) AND 1970 (INFANT)  */
/* ---------------------------------------------------------------- */
```

Each of the cells in CAR7 is now further subdivided into a theoretical maximum of four cells, based on the occupant's restraint use (REST3): 0 = unrestrained, 2 = lap belt, 3 = lap plus shoulder belt, 4 = child safety seat. OLDFA14 generally tabulates the belt use of fatally injured occupants in CY 1975 (i.e., before the temporary decline of belt use in the late 1970's). Only if there are insufficient cases from CY 1975 does OLDFA14 also include data from later calendar years. Eight scenarios are considered:

- RES0, cells where REST3 is always set to zero, either because restraints do not exist (e.g., non-designated seat positions, or infants before the existence of infant seats) or because belt use is so rare that there are no cases of restrained occupant fatalities on *FARS7580* (e.g., center-front occupants before MY 1967).
- INF1, infants in designated seat positions, after the existence of infant seats. REST3 can be 0 or 4.
- TOD11, toddlers after the existence of child seats. REST3 can be 0, 2 or 4.
- TOD21, toddlers before the existence of child seats. REST3 can be 0 or 2.
- FOB11, front-outboard occupants age 5+ in MY 1974-75, when all cars had 3-point belts. REST3 can be 0 or 3.
- FOB21, front-outboard occupants age 5+ in MY 1968-73, when most cars had separate lap and shoulder belts (and some had 3-point belts). REST3 can be 0, 2 or 3.
- FOB31, front-outboard occupants age 5+ in MY ≤ 1967, when most cars lap belts only (although a few had 3-point belts, there is not a single fatality case in 1975-80). REST3 can be 0 or 2.
- LAP1, occupants age 5+ at all other seat positions where there is some lap belt use. REST3 can be 0 or 2.

```
DATA RES0(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP REST3)
     INF1(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP)
     TOD11(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP)
     TOD21(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP)
     FOB11(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP)
     FOB21(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP)
     FOB31(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP)
     LAP1(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP);
SET CAR7;
IF SEAT2 IN (18,28,51,52) OR (AGEGP=0 AND CY LT 1970) OR
    (SEAT2=12 AND MY LT 1967) OR (SEAT2=21 AND MY LT 1964) OR
    (SEAT2=22 AND MY LT 1967) THEN DO; REST3=0; OUTPUT RES0; END;
  ELSE IF AGEGP=0 THEN OUTPUT INF1;
  ELSE IF AGEGP=1 AND 1967 LE CY LE 1974 THEN OUTPUT TOD11;
  ELSE IF AGEGP=1 THEN OUTPUT TOD21;
  ELSE IF SEAT2 IN (11,13) AND 1974 LE MY LE 1975 THEN OUTPUT FOB11;
  ELSE IF SEAT2 IN (11,13) AND 1968 LE MY LE 1973 THEN OUTPUT FOB21;
  ELSE IF SEAT2 IN (11,13) THEN OUTPUT FOB31;
  ELSE OUTPUT LAP1;
RUN;
```

```
DATA INF2(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP REST3);
SET INF1;
OLDWT=ORIGWT;
```

OLDFA14 shows 4.34 percent of infant fatality cases were restrained in a safety seat in CY 1975-78 (i.e., before child passenger safety laws took effect). Given that infant seats first became available in CY 1970, we will assume a gradual increase in use from 1970, reaching 4.34 percent in 1974. Because the safety seat is not part of the car's original equipment, the MY of the car is not as important a factor as the CY of the crash (and for simplicity, only the CY is considered here).

```
CRDUSE=.0434*(CY-1969)/5;                                  /* FROM OLDFA14, P. 1 */
```

The original cell is split into two cells, one for restrained infants, one unrestrained. For example, if there were 100 infant fatalities in MY 1974 (ORIGWT = 100), we will create one cell of restrained infants with ORIGWT = 4.34 and one cell of unrestrained infants with ORIGWT = 95.66.

```
REST3=4; ORIGWT=   CRDUSE *OLDWT; OUTPUT;
REST3=0; ORIGWT=(1-CRDUSE)*OLDWT; OUTPUT;
RUN;

DATA TOD12(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP REST3);
SET TOD11;
OLDWT=ORIGWT;
```

1.59 percent of toddler fatalities were restrained in safety seats in CY 1975-78. Given that toddler seats first became available in CY 1967, but more widely starting in1970, we will assume a slow increase in 1967-69, and a faster increase in use from 1970, reaching 1.59 percent in 1974.

```
IF 1970 LE CY LE 1974 THEN CRDUSE=.0159*(CY-1969)/5;     /* FROM OLDFA14, P. 2 */
  ELSE IF 1967 LE CY LE 1969 THEN CRDUSE=.0159*(CY-1966)/20;
```

Lap belt use by toddlers was close to 1 percent, and depends more on the model year of the vehicle than the calendar year of the crash.

```
IF MY GE 1955 THEN LAPUSE=.0118; ELSE LAPUSE=.0099;      /* .0118 FROM OLDFA14, P. 2 */
REST3=4; ORIGWT=           CRDUSE  *OLDWT; OUTPUT;       /* .0099 FROM OLDFA14, P. 11 */
REST3=2; ORIGWT=           LAPUSE  *OLDWT; OUTPUT;
REST3=0; ORIGWT=(1-(CRDUSE+LAPUSE))*OLDWT; OUTPUT;
RUN;

DATA TOD22(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP REST3);
SET TOD21;
OLDWT=ORIGWT;
IF MY GE 1955 THEN LAPUSE=.0118; ELSE LAPUSE=.0099;      /* .0118 FROM OLDFA14, P. 2 */
REST3=2; ORIGWT=   LAPUSE *OLDWT; OUTPUT;                /* .0099 FROM OLDFA14, P. 11 */
REST3=0; ORIGWT=(1-LAPUSE)*OLDWT; OUTPUT;
RUN;

DATA FOB12(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP REST3);
SET FOB11;
OLDWT=ORIGWT;
```

In CY 1975, 10.61 percent of front-outboard fatalities age 5+ in MY 1974-75 cars were restrained by 3-point belts.

```
REST3=3; ORIGWT=.1061*OLDWT; OUTPUT;                     /* FROM OLDFA14, P. 12 */
REST3=0; ORIGWT=.8939*OLDWT; OUTPUT;
RUN;
```

```
DATA FOB22(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP REST3);
SET FOB21;
OLDWT=ORIGWT;
```

In CY 1975, depending on the model year, the percentage of front-outboard fatalities wearing lap belts only ranged from 2.47 to 6.42 percent (REST_USE = 2 or 8 on FARS). Far fewer were explicitly coded as also using the shoulder belt (REST_USE = 3).

```
IF MY=1968 THEN LS_USE=.0011; ELSE IF 1969 LE MY LE 1970 THEN LS_USE=.0051;
  ELSE IF MY=1971 THEN LS_USE=.0081; ELSE IF MY=1972 THEN LS_USE=.0099;
  ELSE IF MY=1973 THEN LS_USE=.0112;
IF MY=1968 THEN LAPUSE=.0247; ELSE IF 1969 LE MY LE 1971 THEN LAPUSE=.0366;
  ELSE IF 1972 LE MY LE 1973 THEN LAPUSE=.0642;          /* FROM OLDFA14, P. 12 */
REST3=3; ORIGWT=           LS_USE  *OLDWT; OUTPUT;
REST3=2; ORIGWT=           LAPUSE  *OLDWT; OUTPUT;
REST3=0; ORIGWT=(1-(LS_USE+LAPUSE))*OLDWT; OUTPUT;
RUN;

DATA FOB32(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP REST3);
SET FOB31;
OLDWT=ORIGWT;
```

In pre-1968 cars, 1 to 2 percent of front-outboard fatalities were lap-belted. Belt use is lower in model years before 1964, because many cars did not have any safety belts installed. These rates are based on CY 1975-80 FARS data because there are not enough cases in CY 1975 alone for meaningful rates.

```
IF 1964 LE MY LE 1967 THEN LAPUSE=.0195;                /* FROM OLDFA14, P. 11 */
  ELSE IF 1955 LE MY LE 1963 THEN LAPUSE=.0131;
  ELSE LAPUSE=.0099;
REST3=2; ORIGWT=   LAPUSE *OLDWT; OUTPUT;
REST3=0; ORIGWT=(1-LAPUSE)*OLDWT; OUTPUT;
RUN;

DATA LAP2(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP REST3);
SET LAP1;
OLDWT=ORIGWT;
```

Lap belt use of fatally injured occupants in the rear-outboard seats, MY 1964-74 and the center seats, MY 1967-74.

```
IF SEAT2=12 THEN LAPUSE=.0145;                          /* FROM OLDFA14, P. 13 */
  ELSE IF SEAT2=21 AND MY GE 1972 THEN LAPUSE=.0374;    /* FROM OLDFA14, P. 15 */
  ELSE IF SEAT2=21 THEN LAPUSE=.0109;                   /* FROM OLDFA14, P. 14 */
  ELSE IF SEAT2=22 THEN LAPUSE=.0049;                   /* FROM OLDFA14, P. 16 */
REST3=2; ORIGWT=   LAPUSE *OLDWT; OUTPUT;
REST3=0; ORIGWT=(1-LAPUSE)*OLDWT; OUTPUT;
RUN;

/* ------------------------------------------------------------------ */
/*  CAR8 IS THE FULL ANALYSIS FILE                                    */
/*  EJECT2 IS PROPORTION OF FATALITIES EJECTED IN EACH CELL           */
/* ------------------------------------------------------------------ */

DATA CAR8; SET RES0 INF2 TOD12 TOD22 FOB12 FOB22 FOB32 LAP2;
WEIGHTFA=ORIGWT;
```

CAR8 has a separate record (cell) for each permissible combination of CY, MY, CRSH, SEAT2, AGEGP and REST3. As in LS2004, we also need to know EJECT2, the probability that a fatality was ejected. Unlike LS2004, we do not know whether specific individuals were ejected (the

EJECTION variable on FARS) because, more generally, CAR8 does not have information on specific crashes. We only have an overall proportion ejected (EJECT2). It is based on the OLDFA14 analysis of *FARS7580*. For simplicity, we will use one set of EJECT2 values, by crash mode, for all unrestrained fatalities, and another set for all restrained fatalities; we will not further subdivide by seat position or occupant age group. CY, MY, CRSH, SEAT2, AGEGP, REST3 and EJECT2 are all the core variables needed to estimate the lives saved by technologies available in 1960-74.

ORIGWT is the number of car-occupant fatalities in that cell.

```
IF REST3=0 THEN DO;
  IF CRSH=1 THEN EJECT2=.1549; ELSE IF CRSH=2.1 THEN EJECT2=.2779;   /* FROM OLDFA14, P. 9 */
    ELSE IF CRSH=2.2 THEN EJECT2=.1499; ELSE IF CRSH=3 THEN EJECT2=.5556;
    ELSE IF CRSH=4 THEN EJECT2=.2273; END;
ELSE DO;
  IF CRSH=1 THEN EJECT2=.0562; ELSE IF CRSH=2.1 THEN EJECT2=.1537;   /* FROM OLDFA14, P. 10 */
    ELSE IF CRSH=2.2 THEN EJECT2=.0627; ELSE IF CRSH=3 THEN EJECT2=.2387;
    ELSE IF CRSH=4 THEN EJECT2=.0923; END;
RUN;

PROC SORT DATA=CAR8; BY CY;
RUN;

/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
/*  REPEATS THE CAR OCCUPANT ANALYSIS OF LS2004.SAS                   */
/*                                                                    */
/*  HAS TO BE SIMPLIFIED FOR 203, 212, 214 SINCE VIN/MAKE-MODEL UNK   */
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
```

The estimation of lives saved by the various safety technologies closely parallels the "DATA CAR2; SET CAR1;" step of LS2004.

Three "tags" of information accompany each cell as it processes through the model:

- ORIGWT, the original number of fatalities in the cell, remains unchanged.
- WEIGHTFA, the inflated cell fatality count, grows as safety technologies are "removed" from the vehicle. The existence of ORIGWT fatalities in a cell containing vehicles equipped certain safety technologies implies that there would have been WEIGHTFA fatalities if the vehicle had no safety technologies at all, in the sense that the combined effectiveness of these technologies would reduce WEIGHTFA fatalities to ORIGWT fatalities.
- EJECT2, the probability that an occupant in this cell was ejected. Belts reduce the probability of ejection, whereas other technologies, such as improved door locks, are effective only if the occupant was ejected. Thus, it is necessary to track the changing probability of ejection as technologies are removed.

```
DATA CAR9; SET CAR8;

/* ------------------------------------------------------------------ */
/*  ZERO BENEFITS FOR TECHNOLOGIES NOT AVAILABLE IN 1960-74           */
/* ------------------------------------------------------------------ */
```

The first difference from LS2004 is that seven of the later technologies in LS2004 did not exist in any car on the road in CY 1960-74. We may skip the analyses and set the lives saved to zero.

```
PS208J=0; PV208J=0; CLS208J=0; CLV208J=0; CL208J=0;
PS108=0; PV108=0; CLS108=0; CLV108=0; CL108=0;
PS208I=0; PV208I=0; CLS208I=0; CLV208I=0; CL208I=0;
PS214B=0; PV214B=0; CLS214B=0; CLV214B=0; CL214B=0;
PS208H=0; PV208H=0; CLS208H=0; CLV208H=0; CL208H=0;
PS208G=0; PV208G=0; CLS208G=0; CLV208G=0; CL208G=0;
PSNCAP=0; PVNCAP=0; CLSNCAP=0; CLVNCAP=0; CLNCAP=0;
CLS=0; CLV=0; CL=0;

/* ------------------------------------------------------------------ */
/*  213 CHILD SAFETY SEATS                                            */
/*  USE RATE WENT OVER 50% IN: 1985                                   */
/* ------------------------------------------------------------------ */
```

Even though the "median installation year" is 1985, some children were in safety seats long before that, and well before 1974. We must proceed to estimate lives saved.

```
/* IDENTIFIES CHILD PASSENGERS IN SAFETY SEATS  */
```

Benefits are estimated for those cells where every child was in a safety seat (REST3 = 4). The sizes of those cells (ORIGWT), as discussed above, depends on the use rate for safety seats.

```
  PS213=0; IF REST3=4 THEN PV213=1; ELSE PV213=0;
/* LIVES SAVED AND EJECTIONS PREVENTED BY CHILD SAFETY SEATS */
  OLDWTFA=WEIGHTFA;
  IF PS213 GT 0 OR PV213 GT 0 THEN DO;
    IF AGEGP=0 THEN E=.71; ELSE E=.54;
```

When we "remove" a restraint system from the vehicle, the occupant becomes unrestrained and, in general, 15.49 percent of unrestrained fatalities in frontal crashes were ejected, 27.79 percent in single-vehicle side impacts, etc. (These probabilities are the same as for the originally unrestrained occupants in the DATA CAR8 step above, and are generated by OLDFA14. The same probabilities will be used for all subsequent groups of transformed-to-unrestrained car occupants.) One of these becomes the new values of EJECT2 as this now-unrestrained occupant fatality cell proceeds through the rest of the model.

```
    IF CRSH=1 THEN EJECT2=.1549; ELSE IF CRSH=2.1 THEN EJECT2=.2779;   /* FROM OLDFA14, P. 9 */
      ELSE IF CRSH=2.2 THEN EJECT2=.1499; ELSE IF CRSH=3 THEN EJECT2=.5556;
      ELSE IF CRSH=4 THEN EJECT2=.2273;
    P=PS213+PV213;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS213=S*PS213/P;
    CLV213=S*PV213/P;
    WEIGHTFA=OLDWTFA+CLS213+CLV213; END;
  ELSE DO; CLS213=0; CLV213=0; END;
  CL213=CLS213+CLV213;
  CLS=CLS+CLS213; CLV=CLV+CLV213; CL=CL+CL213;

/* ------------------------------------------------------------------ */
/*  208F 3-POINT BELTS FOR FRONT-SEAT OUTBOARD OCCUPANTS              */
```

Includes occupants who buckle both belts in 1968-73 cars with separate lap and shoulder belts.

```
/*  MEDIAN INSTALLATION YEAR: 1974                                    */
/* ------------------------------------------------------------------ */

/* IDENTIFIES FRONT-SEAT OCCUPANTS WEARING 3-POINT BELTS  */
```

```
  PS208F=0; PV208F=0;
  IF SEAT2 IN (11,13) AND REST3=3 THEN DO; IF MY LE 1973 THEN PV208F=1; ELSE PS208F=1; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY FRONT-OUTBOARD 3-POINT BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208F GT 0 OR PV208F GT 0 THEN DO;
```

Unlike LS2004, which has many different effectiveness values depending on the crash mode, we will for simplicity use the overall average fatality reduction by lap/shoulder belts: 45 percent.

```
    E=.45;
    IF CRSH=1 THEN EJECT2=.1549; ELSE IF CRSH=2.1 THEN EJECT2=.2779;   /* FROM OLDFA14, P. 9 */
      ELSE IF CRSH=2.2 THEN EJECT2=.1499; ELSE IF CRSH=3 THEN EJECT2=.5556;
      ELSE IF CRSH=4 THEN EJECT2=.2273;
    P=PS208F+PV208F;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208F=S*PS208F/P;
    CLV208F=S*PV208F/P;
    WEIGHTFA=OLDWTFA+CLS208F+CLV208F; END;
  ELSE DO; CLS208F=0; CLV208F=0; END;
  CL208F=CLS208F+CLV208F;
  CLS=CLS+CLS208F; CLV=CLV+CLV208F; CL=CL+CL208F;

/* ------------------------------------------------------------------ */
/*  216 B-PILLARS FOR HARDTOP CARS AND OTHER ROOF STRENGTHENING       */
/*  MEDIAN INSTALLATION YEAR: 1973                                    */
/* ------------------------------------------------------------------ */
```

Same code as LS2004. For the remaining technologies, if the code is also the same as in LS2004, notes will be omitted.

```
/* ROOF STRENGTH IMPROVED GRADUALLY FROM 1970 TO 1977       */
  IF MY LE 1969 THEN DO; PS216=0; PV216=0; END;
    ELSE IF 1970 LE MY LE 1973 THEN DO; PS216=0; PV216=.125*(MY-1969); END;
    ELSE IF 1974 LE MY LE 1976 THEN DO; PS216=.125*(MY-1969); PV216=0; END;
/* REDUCTION IN NONEJECTION ROLLOVER FATALITY RISK WITH IMPROVED ROOF STRENGTH */
  OLDWTFA=WEIGHTFA;
  IF (PS216 GT 0 OR PV216 GT 0) AND CRSH=3
      AND SEAT2 NE 52 AND EJECT2 NE 1 THEN DO;
    E=.074;
    P=PS216+PV216;
    REL_S=(1-EJECT2)*E*P / (1 - E*P);
    S=OLDWTFA*REL_S;
    CLS216=S*PS216/P;
    CLV216=S*PV216/P;
    WEIGHTFA=OLDWTFA+CLS216+CLV216;
    EJECT2=EJECT2/(1+ REL_S); END;
  ELSE DO; CLS216=0; CLV216=0; END;
  CL216=CLS216+CLV216;
  CLS=CLS+CLS216; CLV=CLV+CLV216; CL=CL+CL216;

/* ------------------------------------------------------------------ */
/*  214A SIDE DOOR BEAMS                                              */
/*  MEDIAN INSTALLATION YEAR: EARLY 1973                              */
/* ------------------------------------------------------------------ */

/* IDENTIFIES CARS WITH SIDE DOOR BEAMS                    */
```

In LS2004, we could identify the specific vehicles equipped with side door beams, based on the VIN; PS214A and PV214A were either 1 or 0. Here, we can only find the proportion of vehicles in each cell with side door beams, based on the model year. A tabulation near the end of LS2004 indicates that side door beams were in 17 percent of MY 1969 cars, 35 percent in 1970, 44 percent in 1971, 49 percent in 1972 and 85 percent in 1973 (the standard took effect in mid-MY 1973).

```
  IF MY GE 1974 THEN DO; PS214A=1; PV214A=0; END;
    ELSE IF MY LE 1968 THEN DO; PS214A=0; PV214A=0; END;
    ELSE IF MY=1969 THEN DO; PS214A=0; PV214A=.17; END;            /* FROM LS2004 */
    ELSE IF MY=1970 THEN DO; PS214A=0; PV214A=.35; END;
    ELSE IF MY=1971 THEN DO; PS214A=0; PV214A=.44; END;
    ELSE IF MY=1972 THEN DO; PS214A=0; PV214A=.49; END;
    ELSE IF MY=1973 AND CY=1972 THEN DO; PS214A=0; PV214A=.85; END;
    ELSE IF MY=1973 THEN DO; PS214A=.50; PV214A=.35; END;
/* REDUCTION IN SINGLE-VEHICLE SIDE-IMPACT FATALITIES WITH SIDE DOOR BEAMS     */
  OLDWTFA=WEIGHTFA;
  IF (PS214A GT 0 OR PV214A GT 0) AND CRSH=2.1 AND SEAT2 IN (11,13,21) THEN DO;
    E=.14;
    P=PS214A+PV214A;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS214A=S*PS214A/P;
    CLV214A=S*PV214A/P;
    WEIGHTFA=OLDWTFA+CLS214A+CLV214A; END;
  ELSE DO; CLS214A=0; CLV214A=0; END;
  CL214A=CLS214A+CLV214A;
  CLS=CLS+CLS214A; CLV=CLV+CLV214A; CL=CL+CL214A;
```

```
/* ---------------------------------------------------------------- */
/*  105B FRONT DISC BRAKES                                          */
/*  MEDIAN INSTALLATION YEAR: 1971 (INSTALLATION COMPLETED 1977)    */
/* ---------------------------------------------------------------- */

/* IMPLEMENTATION OF FRONT DISC BRAKES */
  IF MY GE 1977 THEN DO; PS105B=1; PV105B=0; END;
    ELSE IF MY LE 1964 THEN DO; PS105B=0; PV105B=0; END;
    ELSE IF MY=1965 THEN DO; PS105B=0; PV105B=.02; END;
    ELSE IF MY=1966 THEN DO; PS105B=0; PV105B=.03; END;
    ELSE IF MY=1967 THEN DO; PS105B=0; PV105B=.06; END;
    ELSE IF MY=1968 THEN DO; PS105B=0; PV105B=.13; END;
    ELSE IF MY=1969 THEN DO; PS105B=0; PV105B=.28; END;
    ELSE IF MY=1970 THEN DO; PS105B=0; PV105B=.41; END;
    ELSE IF MY=1971 THEN DO; PS105B=0; PV105B=.63; END;
    ELSE IF MY=1972 THEN DO; PS105B=0; PV105B=.74; END;
    ELSE IF MY=1973 THEN DO; PS105B=0; PV105B=.86; END;
    ELSE IF MY=1974 THEN DO; PS105B=0; PV105B=.84; END;
    ELSE IF MY=1975 THEN DO; PS105B=0; PV105B=.93; END;
/* CAR OCCUPANT LIVES SAVED BY FRONT DISC BRAKES */
  OLDWTFA=WEIGHTFA;
  IF PS105B GT 0 OR PV105B GT 0 THEN DO;
    E=.0017;
    P=PS105B+PV105B;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS105B=S*PS105B/P;
    CLV105B=S*PV105B/P;
    WEIGHTFA=OLDWTFA+CLS105B+CLV105B; END;
  ELSE DO; CLS105B=0; CLV105B=0; END;
  CL105B=CLS105B+CLV105B;
  CLS=CLS+CLS105B; CLV=CLV+CLV105B; CL=CL+CL105B;

/* ---------------------------------------------------------------- */
/*  201 VOLUNTARY INSTRUMENT PANEL IMPROVEMENTS (FMVSS-201 INSPIRED)  */
/*  MEDIAN IMPLEMENTATION YEAR: 1968                                */
/* ---------------------------------------------------------------- */

/* IDENTIFIES CARS WITH VOLUNTARY INSTRUMENT PANEL IMPROVEMENTS   */
  PS201=0; PV201=0;
  IF MY GE 1967 AND SEAT2=13 THEN DO;
      IF MY GE 1973 THEN PV201=1;
        ELSE IF MY=1967 THEN PV201=.25; ELSE IF MY=1968 THEN PV201=.5;
        ELSE IF MY=1969 THEN PV201=.6;  ELSE IF MY=1970 THEN PV201=.7;
        ELSE IF MY=1971 THEN PV201=.8;  ELSE IF MY=1972 THEN PV201=.9; END;
/* LIVES SAVED IN FRONTAL IMPACTS BY INSTRUMENT PANEL IMPROVEMENTS */
  OLDWTFA=WEIGHTFA;
  IF PS201 GT 0 OR PV201 GT 0 THEN DO;
    IF CRSH=1 AND REST3 NE 2 THEN E=.159; ELSE E=0;
    P=PS201+PV201;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS201=S*PS201/P;
    CLV201=S*PV201/P;
    WEIGHTFA=OLDWTFA+CLS201+CLV201; END;
  ELSE DO; CLS201=0; CLV201=0; END;
  CL201=CLS201+CLV201;
  CLS=CLS+CLS201; CLV=CLV+CLV201; CL=CL+CL201;

/* ---------------------------------------------------------------- */
/*  203 ENERGY-ABSORBING AND TELESCOPING STEERING ASSEMBLIES         */
/*  MEDIAN IMPLEMENTATION YEAR: 1967                                */
/* ---------------------------------------------------------------- */

/* IDENTIFIES CARS WITH ENERGY-ABSORBING STEERING ASSEMBLIES      */
  PS203=0; PV203=0;
  IF MY GE 1967 AND SEAT2=11 THEN DO;
```

LS2004 indicates that 62 percent of MY 1967 cars (and all MY 1968 cars) were equipped with energy-absorbing steering assemblies.

```
      IF MY GE 1969 THEN PS203=1;
        ELSE IF MY=1968 AND CY=1967 THEN PV203=1;
        ELSE IF MY=1968 THEN DO; PS203=.5; PV203=.5; END;           /* FROM LS2004 */
        ELSE IF MY=1967 THEN PV203=.62; END;
/* LIVES SAVED IN FRONTAL IMPACTS BY INSTRUMENT PANEL IMPROVEMENTS */
  OLDWTFA=WEIGHTFA;
  IF PS203 GT 0 OR PV203 GT 0 THEN DO;
    IF CRSH=1 THEN E=.121; ELSE E=0;
    P=PS203+PV203;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS203=S*PS203/P;
    CLV203=S*PV203/P;
    WEIGHTFA=OLDWTFA+CLS203+CLV203; END;
  ELSE DO; CLS203=0; CLV203=0; END;
  CL203=CLS203+CLV203;
  CLS=CLS+CLS203; CLV=CLV+CLV203; CL=CL+CL203;

/* ---------------------------------------------------------------- */
/*  208E LAP BELTS FOR BACK-SEAT CENTER OCCUPANTS                   */
/*  MEDIAN INSTALLATION YEAR: EARLY 1967                            */
/* ---------------------------------------------------------------- */

/* IDENTIFIES BACK-CENTER-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208E=0; PV208E=0;
  IF SEAT2=22 AND REST3=2 AND AGEGP=5 THEN DO;
     IF MY GE 1969 THEN PS208E=1;
       ELSE IF MY LE 1967 THEN PV208E=1;
       ELSE IF MY=1968 AND CY=1967 THEN PV208E=1;
       ELSE IF MY=1968 THEN DO; PS208E=.5; PV208E=.5; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY BACK-CENTER-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208E GT 0 OR PV208E GT 0 THEN DO;
```

NHTSA's evaluation estimates an overall 32 percent fatality reduction by lap belts for rear-outboard occupants. The same effectiveness is assumed for the rear-center occupant.

```
    E=.32;
    IF CRSH=1 THEN EJECT2=.1549; ELSE IF CRSH=2.1 THEN EJECT2=.2779;   /* FROM OLDFA14, P. 9 */
      ELSE IF CRSH=2.2 THEN EJECT2=.1499; ELSE IF CRSH=3 THEN EJECT2=.5556;
      ELSE IF CRSH=4 THEN EJECT2=.2273;
    P=PS208E+PV208E;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208E=S*PS208E/P;
    CLV208E=S*PV208E/P;
    WEIGHTFA=OLDWTFA+CLS208E+CLV208E; END;
  ELSE DO; CLS208E=0; CLV208E=0; END;
  CL208E=CLS208E+CLV208E;
  CLS=CLS+CLS208E; CLV=CLV+CLV208E; CL=CL+CL208E;

/* ---------------------------------------------------------------- */
/*  105A DUAL MASTER CYLINDERS                                      */
/*  MEDIAN INSTALLATION YEAR: LATE 1966                             */
/* ---------------------------------------------------------------- */

/* IMPLEMENTATION OF DUAL MASTER CYLINDERS */
  IF MY GE 1969 THEN DO; PS105A=1; PV105A=0; END;
    ELSE IF MY LE 1961 THEN DO; PS105A=0; PV105A=0; END;
    ELSE IF MY IN (1962,1963) THEN DO; PS105A=0; PV105A=.09; END;
    ELSE IF MY IN (1964,1965) THEN DO; PS105A=0; PV105A=.07; END;
    ELSE IF MY=1966 THEN DO; PS105A=0; PV105A=.54; END;
```

```
    ELSE IF MY=1967 THEN DO; PS105A=0; PV105A=1; END;
    ELSE IF MY=1968 AND CY=1967 THEN DO; PS105A=0; PV105A=1; END;
    ELSE IF MY=1968 THEN DO; PS105A=.5; PV105A=.5; END;
/* CAR OCCUPANT LIVES SAVED BY DUAL MASTER CYLINDERS */
  OLDWTFA=WEIGHTFA;
  IF PS105A GT 0 OR PV105A GT 0 THEN DO;
    E=.007;
    P=PS105A+PV105A;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS105A=S*PS105A/P;
    CLV105A=S*PV105A/P;
    WEIGHTFA=OLDWTFA+CLS105A+CLV105A; END;
  ELSE DO; CLS105A=0; CLV105A=0; END;
  CL105A=CLS105A+CLV105A;
  CLS=CLS+CLS105A; CLV=CLV+CLV105A; CL=CL+CL105A;

/* ---------------------------------------------------------------- */
/*  208D LAP BELTS FOR FRONT-SEAT CENTER OCCUPANTS                  */
/*  MEDIAN INSTALLATION YEAR: 1966                                  */
/* ---------------------------------------------------------------- */

/* IDENTIFIES FRONT-CENTER-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208D=0; PV208D=0;
  IF SEAT2=12 AND REST3=2 AND AGEGP=5 THEN DO;
     IF MY GE 1969 THEN PS208D=1;
       ELSE IF MY LE 1967 THEN PV208D=1;
       ELSE IF MY=1968 AND CY=1967 THEN PV208D=1;
       ELSE IF MY=1968 THEN DO; PS208D=.5; PV208D=.5; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY FRONT-CENTER-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208D GT 0 OR PV208D GT 0 THEN DO;
```

A double-pair comparison analysis of lap belt effectiveness for front-outboard occupants, conducted in support of this study, found 27 percent overall fatality reduction. The same effectiveness is assumed for front-center occupants.

```
    E=.27;
    IF CRSH=1 THEN EJECT2=.1549; ELSE IF CRSH=2.1 THEN EJECT2=.2779;   /* FROM OLDFA14, P. 9 */
      ELSE IF CRSH=2.2 THEN EJECT2=.1499; ELSE IF CRSH=3 THEN EJECT2=.5556;
      ELSE IF CRSH=4 THEN EJECT2=.2273;
    P=PS208D+PV208D;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208D=S*PS208D/P;
    CLV208D=S*PV208D/P;
    WEIGHTFA=OLDWTFA+CLS208D+CLV208D; END;
  ELSE DO; CLS208D=0; CLV208D=0; END;
  CL208D=CLS208D+CLV208D;
  CLS=CLS+CLS208D; CLV=CLV+CLV208D; CL=CL+CL208D;

/* ---------------------------------------------------------------- */
/*  212 ADHESIVE WINDSHIELD BONDING                                 */
/*  MEDIAN INSTALLATION YEAR: EARLY 1966                            */
/* ---------------------------------------------------------------- */

/* IDENTIFIES CARS WITH ADHESIVE WINDSHIELD BONDING        */
  IF MY LE 1962 THEN DO; PS212=0; PV212=0; END;
```

LS2004 tabulates the proportion of cars with adhesive windshield bonding, by model year.

```
    ELSE IF MY=1963 THEN DO; PS212=0; PV212=.02; END;         /* FROM LS2004 */
    ELSE IF MY=1964 THEN DO; PS212=0; PV212=.11; END;
    ELSE IF MY=1965 THEN DO; PS212=0; PV212=.48; END;
    ELSE IF MY=1966 THEN DO; PS212=0; PV212=.56; END;
    ELSE IF MY=1967 THEN DO; PS212=0; PV212=.60; END;
```

```
    ELSE IF MY=1968 THEN DO; PS212=0; PV212=.65; END;
    ELSE IF MY=1969 THEN DO; PS212=0; PV212=.75; END;
    ELSE IF MY=1970 AND CY=1969 THEN DO; PS212=0; PV212=.73; END;
    ELSE IF MY=1970 THEN DO; PS212=.39; PV212=.34; END;
    ELSE IF MY=1971 THEN DO; PS212=.74; PV212=0; END;
    ELSE IF MY=1972 THEN DO; PS212=.74; PV212=0; END;
    ELSE IF MY=1973 THEN DO; PS212=.77; PV212=0; END;
    ELSE IF MY=1974 THEN DO; PS212=.69; PV212=0; END;
    ELSE IF MY=1975 THEN DO; PS212=.71; PV212=0; END;
/* REDUCTION IN EJECTION FATALITY RISK WITH ADHESIVE WINDSHIELD BONDING */
  OLDWTFA=WEIGHTFA;
  IF (PS212 GT 0 OR PV212 GT 0) AND SEAT2 IN (11,12,13,18) AND EJECT2 NE 0 THEN DO;
    IF CRSH IN (1,3) THEN E=.033;
      ELSE IF CRSH IN (2.1,2.2,4) THEN E=.0075;
    P=PS212+PV212;
    REL_S=EJECT2*E*P / (1 - E*P);
    S=OLDWTFA*REL_S;
    CLS212=S*PS212/P;
    CLV212=S*PV212/P;
    WEIGHTFA=OLDWTFA+CLS212+CLV212;
    EJECT2=(EJECT2 + REL_S)/(1 + REL_S); END;
  ELSE DO; CLS212=0; CLV212=0; END;
  CL212=CLS212+CLV212;
  CLS=CLS+CLS212; CLV=CLV+CLV212; CL=CL+CL212;

/* ---------------------------------------------------------------- */
/*  208C LAP BELTS FOR BACK-SEAT OUTBOARD OCCUPANTS                 */
/*  MEDIAN INSTALLATION YEAR: LATE 1965                             */
/* ---------------------------------------------------------------- */

/* IDENTIFIES BACK-OUTBOARD-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208C=0; PV208C=0;
  IF SEAT2=21 AND REST3=2 AND AGEGP=5 THEN DO;
     IF MY GE 1969 THEN PS208C=1;
       ELSE IF MY LE 1967 THEN PV208C=1;
       ELSE IF MY=1968 AND CY=1967 THEN PV208C=1;
       ELSE IF MY=1968 THEN DO; PS208C=.5; PV208C=.5; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY BACK-OUTBOARD-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208C GT 0 OR PV208C GT 0 THEN DO;
```

NHTSA's evaluation estimates an overall 32 percent fatality reduction by lap belts for rear-outboard occupants.

```
    E=.32;
    IF CRSH=1 THEN EJECT2=.1549; ELSE IF CRSH=2.1 THEN EJECT2=.2779;   /* FROM OLDFA14, P. 9 */
      ELSE IF CRSH=2.2 THEN EJECT2=.1499; ELSE IF CRSH=3 THEN EJECT2=.5556;
      ELSE IF CRSH=4 THEN EJECT2=.2273;
    P=PS208C+PV208C;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208C=S*PS208C/P;
    CLV208C=S*PV208C/P;
    WEIGHTFA=OLDWTFA+CLS208C+CLV208C; END;
  ELSE DO; CLS208C=0; CLV208C=0; END;
  CL208C=CLS208C+CLV208C;
  CLS=CLS+CLS208C; CLV=CLV+CLV208C; CL=CL+CL208C;

/* ---------------------------------------------------------------- */
/*  206 DOOR LOCK IMPROVEMENTS                                      */
/*  MEDIAN INSTALLATION YEAR: 1965                                  */
/* ---------------------------------------------------------------- */

/* DOOR LOCKS IMPROVED GRADUALLY FROM 1962 TO 1968       */
  IF MY GE 1969 THEN DO; PS206=1; PV206=0; END;
```

```
    ELSE IF MY=1968 AND CY=1967 THEN DO; PS206=0; PV206=1; END;
    ELSE IF MY=1968 THEN DO; PS206=.5; PV206=.5; END;
    ELSE IF 1962 LE MY LE 1967 THEN DO; PS206=0; PV206=(MY-1961)/7; END;
    ELSE IF MY LE 1961 THEN DO; PS206=0; PV206=0; END;
/* REDUCTION IN EJECTION ROLLOVER FATALITY RISK WITH IMPROVED DOOR LOCKS */
  OLDWTFA=WEIGHTFA;
  IF (PS206 GT 0 OR PV206 GT 0) AND CRSH=3
      AND SEAT2 NE 52 AND EJECT2 NE 0 THEN DO;
    E=.1538;
    P=PS206+PV206;
    REL_S=EJECT2*E*P / (1 - E*P);
    S=OLDWTFA*REL_S;
    CLS206=S*PS206/P;
    CLV206=S*PV206/P;
    WEIGHTFA=OLDWTFA+CLS206+CLV206;
    EJECT2=(EJECT2 + REL_S)/(1 + REL_S); END;
  ELSE DO; CLS206=0; CLV206=0; END;
  CL206=CLS206+CLV206;
  CLS=CLS+CLS206; CLV=CLV+CLV206; CL=CL+CL206;

/* ---------------------------------------------------------------- */
/*  208B LAP BELT USE BY CHILDREN AGE 1-4                           */
/*  MEDIAN INSTALLATION YEAR FOR LAP BELTS USED BY CHILDREN: 1964   */
/* ---------------------------------------------------------------- */

/* IDENTIFIES CHILD PASSENGERS AGE 1-4 USING LAP BELTS */
  PS208B=0; PV208B=0;
  IF AGEGP=1 AND REST3=2 THEN DO;
     IF MY GE 1969 THEN PS208B=1;
       ELSE IF MY LE 1967 THEN PV208B=1;
       ELSE IF MY=1968 AND CY=1967 THEN PV208B=1;
       ELSE IF MY=1968 THEN DO; PS208B=.5; PV208B=.5; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY LAP BELTS (AGE 1-4) */
  OLDWTFA=WEIGHTFA;
  IF PS208B GT 0 OR PV208B GT 0 THEN DO;
    E=.33;
    IF CRSH=1 THEN EJECT2=.1549; ELSE IF CRSH=2.1 THEN EJECT2=.2779;   /* FROM OLDFA14, P. 9 */
      ELSE IF CRSH=2.2 THEN EJECT2=.1499; ELSE IF CRSH=3 THEN EJECT2=.5556;
      ELSE IF CRSH=4 THEN EJECT2=.2273;
    P=PS208B+PV208B;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208B=S*PS208B/P;
    CLV208B=S*PV208B/P;
    WEIGHTFA=OLDWTFA+CLS208B+CLV208B; END;
  ELSE DO; CLS208B=0; CLV208B=0; END;
  CL208B=CLS208B+CLV208B;
  CLS=CLS+CLS208B; CLV=CLV+CLV208B; CL=CL+CL208B;

/* ---------------------------------------------------------------- */
/*  208A LAP BELTS FOR FRONT-SEAT OUTBOARD OCCUPANTS                */
/*  MEDIAN INSTALLATION YEAR: 1962                                  */
/* ---------------------------------------------------------------- */

/* IDENTIFIES FRONT-OUTBOARD-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208A=0; PV208A=0;
  IF SEAT2 IN (11,13) AND REST3=2 AND AGEGP=5 THEN DO;
     IF MY GE 1969 THEN PS208A=1;
       ELSE IF MY LE 1967 THEN PV208A=1;
       ELSE IF MY=1968 AND CY=1967 THEN PV208A=1;
       ELSE IF MY=1968 THEN DO; PS208A=.5; PV208A=.5; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY FRONT-OUTBOARD-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208A GT 0 OR PV208A GT 0 THEN DO;
```

A double-pair comparison analysis of lap belt effectiveness for front-outboard occupants, conducted in support of this study, found 27 percent overall fatality reduction.

```
  E=.27;
    IF CRSH=1 THEN EJECT2=.1549; ELSE IF CRSH=2.1 THEN EJECT2=.2779;   /* FROM OLDFA14, P. 9 */
      ELSE IF CRSH=2.2 THEN EJECT2=.1499; ELSE IF CRSH=3 THEN EJECT2=.5556;
      ELSE IF CRSH=4 THEN EJECT2=.2273;
    P=PS208A+PV208A;
    S=OLDWTFA*E*P / (1 - E*P);
    CLS208A=S*PS208A/P;
    CLV208A=S*PV208A/P;
    WEIGHTFA=OLDWTFA+CLS208A+CLV208A; END;
  ELSE DO; CLS208A=0; CLV208A=0; END;
  CL208A=CLS208A+CLV208A;
  CLS=CLS+CLS208A; CLV=CLV+CLV208A; CL=CL+CL208A;
RUN;
```

That concludes the model for passenger cars. It has estimated, on a cell-by-cell basis, by how much fatalities would increase if all the safety technologies were "removed." The next steps are to tally up the lives saved over all the cells, by calendar year, and print the results.

```
PROC MEANS SUM NOPRINT DATA=CAR9; BY CY;
  VAR ORIGWT WEIGHTFA
    CLV208J CLS208J CL208J
    CLV108 CLS108 CL108
    CLV208I CLS208I CL208I
    CLV214B CLS214B CL214B
    CLV208H CLS208H CL208H
    CLV208G CLS208G CL208G
    CLV213 CLS213 CL213
    CLVNCAP CLSNCAP CLNCAP
    CLV208F CLS208F CL208F
    CLV216 CLS216 CL216
    CLV105B CLS105B CL105B
    CLV214A CLS214A CL214A
    CLV208E CLS208E CL208E
    CLV208D CLS208D CL208D
    CLV201 CLS201 CL201
    CLV203 CLS203 CL203
    CLV105A CLS105A CL105A
    CLV208C CLS208C CL208C
    CLV206 CLS206 CL206
    CLV208B CLS208B CL208B
    CLV212 CLS212 CL212
    CLV208A CLS208A CL208A
    CLV CLS CL;
  OUTPUT OUT=CAR10
    SUM=C_ORIGWT C_WTFA
    CLV208J CLS208J CL208J
    CLV108 CLS108 CL108
    CLV208I CLS208I CL208I
    CLV214B CLS214B CL214B
    CLV208H CLS208H CL208H
    CLV208G CLS208G CL208G
    CLV213 CLS213 CL213
    CLVNCAP CLSNCAP CLNCAP
    CLV208F CLS208F CL208F
    CLV216 CLS216 CL216
    CLV105B CLS105B CL105B
    CLV214A CLS214A CL214A
    CLV208E CLS208E CL208E
    CLV208D CLS208D CL208D
    CLV201 CLS201 CL201
```

```
    CLV203 CLS203 CL203
    CLV105A CLS105A CL105A
    CLV208C CLS208C CL208C
    CLV206 CLS206 CL206
    CLV208B CLS208B CL208B
    CLV212 CLS212 CL212
    CLV208A CLS208A CL208A
    CLV CLS CL;

PROC PRINT DATA=CAR10;
  FORMAT CLV208H CLS208H CL208H CLV208G CLS208G CL208G CLV213 CLS213 CL213 9.0;
  ID CY; VAR CLV208H CLS208H CL208H CLV208G CLS208G CL208G CLV213 CLS213 CL213;
  SUM CLV208H CLS208H CL208H CLV208G CLS208G CL208G CLV213 CLS213 CL213;
TITLE1 'CAR OCCUPANT LIVES SAVED BY AUTOMATIC 2-POINT BELTS, BACK-SEAT 3-POINT BELTS, AND CHILD
SAFETY SEATS, 1960-74';
TITLE2 ' ';
TITLE3 '...208H = AUTOMATIC 2-POINT BELTS (PEAK INSTALLATION YEAR 1991, FMVSS PHASE-IN BEGAN
9/1/86)';
TITLE4 '...208G = 3-POINT BELTS FOR BACK-SEAT OCCUPANTS (MEDIAN INSTALLATION YEAR 1989, FMVSS
EFFECTIVE 12/11/89)';
TITLE5 '...213  = CHILD SAFETY SEATS (USE EXCEEDED 50% IN 1985, FMVSS EFFECTIVE 4/1/71, STATE LAWS
1978-85)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=CAR10;
  FORMAT CLVNCAP CLSNCAP CLNCAP CLV208F CLS208F CL208F CLV216 CLS216 CL216 9.0;
  ID CY; VAR CLVNCAP CLNCAP CLV208F CLS208F CL208F CLV216 CLS216 CL216;
  SUM CLVNCAP CLNCAP CLV208F CLS208F CL208F CLV216 CLS216 CL216;
TITLE1 'CAR OCCUPANT LIVES SAVED BY VOLUNTARY NCAP IMPROVEMENTS, FRONT-SEAT 3-POINT BELTS, AND ROOF
CRUSH STRENGTH, 1960-74';
TITLE2 ' ';
TITLE3 '...NCAP = VOLUNTARY NCAP IMPROVEMENTS IN NON-AIR-BAG CARS (MEDIAN IMPLEMENTATION YEAR EARLY
1984)';
TITLE4 '...208F = 3-POINT BELTS FOR FRONT-SEAT OCCUPANTS (MEDIAN INSTALLATION YEAR 1974, FMVSS
EFFECTIVE 9/1/73)';
TITLE5 '...216  = ROOF CRUSH STRENGTH, B-PILLARS, ETC. (MEDIAN INSTALLATION YEAR 1973, FMVSS
EFFECTIVE 9/1/73)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=CAR10;
  FORMAT CLV105B CLS105B CL105B CLV214A CLS214A CL214A CLV208E CLS208E CL208E 9.0;
  ID CY; VAR CLV105B CLS105B CL105B CLV214A CLS214A CL214A CLV208E CLS208E CL208E;
  SUM CLV105B CLS105B CL105B CLV214A CLS214A CL214A CLV208E CLS208E CL208E;
TITLE1 'CAR OCCUPANT LIVES SAVED BY FRONT DISC BRAKES, SIDE DOOR BEAMS, AND BACK-CENTER LAP BELTS,
1960-74';
TITLE2 ' ';
TITLE3 '...105B = FRONT DISC BRAKES (MEDIAN INSTALLATION YEAR 1971, FMVSS EFFECTIVE 1/1/76)';
TITLE4 '...214A = SIDE DOOR BEAMS (MEDIAN INSTALLATION YEAR EARLY 1973, FMVSS EFFECTIVE 1/1/73)';
TITLE5 '...208E = LAP BELTS FOR BACK-CENTER OCCUPANTS (MEDIAN INSTALLATION YEAR EARLY 1967, FMVSS
EFFECTIVE 1/1/68)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=CAR10;
  FORMAT CLV208D CLS208D CL208D CLV201 CL201 CLV203 CLS203 CL203 9.0;
  ID CY; VAR CLV208D CLS208D CL208D CLV201 CL201 CLV203 CLS203 CL203;
  SUM CLV208D CLS208D CL208D CLV201 CL201 CLV203 CLS203 CL203;
TITLE1 'CAR OCCUPANT LIVES SAVED BY FRONT-CENTER LAP BELTS, SAFER INSTRUMENT PANELS, AND EA
STEERING ASSEMBLIES, 1960-74';
TITLE2 ' ';
TITLE3 '...208D = LAP BELTS FOR FRONT-CENTER OCCUPANTS (MEDIAN INSTALLATION YEAR 1966, FMVSS
EFFECTIVE 1/1/68)';
```

```
TITLE4 '...201  = VOLUNTARY INSTRUMENT PANEL IMPROVEMENTS (MEDIAN IMPLEMENTATION YEAR 1968, FMVSS
EFFECTIVE 1/1/68)';
TITLE5 '...203  = ENERGY-ABSORBING STEERING ASSEMBLIES (MEDIAN IMPLEMENTATION YEAR 1967, FMVSS
EFFECTIVE 1/1/68)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=CAR10;
  FORMAT CLV105A CLS105A CL105A CLV208C CLS208C CL208C CLV206 CLS206 CL206 9.0;
  ID CY; VAR CLV105A CLS105A CL105A CLV208C CLS208C CL208C CLV206 CLS206 CL206;
  SUM CLV105A CLS105A CL105A CLV208C CLS208C CL208C CLV206 CLS206 CL206;
TITLE1 'CAR OCCUPANT LIVES SAVED BY DUAL MASTER CYLINDERS, BACK-OUTBOARD LAP BELTS, AND IMPROVED
DOOR LOCKS, 1960-74';
TITLE2 ' ';
TITLE3 '...105A = DUAL MASTER CYLINDERS (MEDIAN INSTALLATION YEAR LATE 1966, FMVSS EFFECTIVE
1/1/68)';
TITLE4 '...208C = LAP BELTS FOR BACK-OUTBOARD OCCUPANTS (MEDIAN INSTALLATION YEAR LATE 1965, FMVSS
EFFECTIVE 1/1/68)';
TITLE5 '...206  = IMPROVED DOOR LOCKS (MEDIAN INSTALLATION YEAR 1965, FMVSS EFFECTIVE 1/1/68)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=CAR10;
  FORMAT CLV208B CLS208B CL208B CLV212 CLS212 CL212 CLV208A CLS208A CL208A 9.0;
  ID CY; VAR CLV208B CLS208B CL208B CLV212 CLS212 CL212 CLV208A CLS208A CL208A;
  SUM CLV208B CLS208B CL208B CLV212 CLS212 CL212 CLV208A CLS208A CL208A;
TITLE1 'CAR OCCUPANT LIVES SAVED BY LAP BELTS FOR CHILDREN AGE 1-4, ADHESIVE WINDSHIELD BONDING,
AND FRONT-OUTBOARD LAP BELTS, 1960-74';
TITLE2 ' ';
TITLE3 '...208B = LAP BELT USE BY CHILDREN AGE 1-4 (MEDIAN INSTALLATION YEAR 1964, FMVSS EFFECTIVE
1/1/68)';
TITLE4 '...212  = ADHESIVE WINDSHIELD BONDING (MEDIAN INSTALLATION YEAR EARLY 1966, FMVSS EFFECTIVE
1/1/70)';
TITLE5 '...208A = LAP BELTS FOR FRONT-OUTBOARD OCCUPANTS (MEDIAN INSTALLATION YEAR 1962, FMVSS
EFFECTIVE 1/1/68)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

DATA CAR11; SET CAR10;
PCT_SAVE=100*CL/C_WTFA;
PROC PRINT DATA=CAR11;
  FORMAT C_ORIGWT C_WTFA CLV CLS CL 9.0 PCT_SAVE 6.2;
  ID CY; VAR C_ORIGWT C_WTFA CLV CLS CL PCT_SAVE;
  SUM C_ORIGWT C_WTFA CLV CLS CL;
TITLE1 'OVERALL CAR OCCUPANT LIVES SAVED BY VEHICLE SAFETY STANDARDS AND TECHNOLOGIES, 1960-74';
TITLE2 ' ';
TITLE3 'C_ORIGWT = ACTUAL CAR OCCUPANT FATALITIES (ESTIMATED)';
TITLE4 'C_WTFA = FATALITIES THAT WOULD HAVE OCCURRED WITHOUT ANY VEHICLE SAFETY IMPROVEMENTS';
TITLE5 'CLV = OVERALL LIVES SAVED BY VOLUNTARY IMPROVEMENTS, BEFORE FMVSS EFFECTIVE DATE';
TITLE6 'CLS = OVERALL LIVES SAVED IN CARS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';
TITLE7 'CL = OVERALL LIVES SAVED BY VEHICLE SAFETY IMPROVEMENTS (CLV + CLS)';
TITLE8 'PCT_SAVE = PERCENT OF WOULD-HAVE-BEEN FATALITIES SAVED BY SAFETY STANDARDS AND
TECHNOLOGIES';
RUN;
```

```
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
/*  THE ANALYSIS OF LIGHT TRUCK OCCUPANTS BEGINS HERE                 */
/*                                                                    */
/*  CREATES A FILE WITH ALL POSSIBLE COMBINATIONS OF                  */
/*  CY, MY, CRASH MODE, OCC AGE GP, SEAT POSITION, RESTRAINT USE      */
/*  ORIGWT IS THE NUMBER OF OCC FATALITIES FOR EACH COMBINATION       */
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */

/* ------------------------------------------------------------------ */
/*  FIRST STEP: ALL CY-MY COMBINATIONS                                */
/*  BASED ON VEHICLE AGE DISTRIBUTION IN 1975-80 FARS                 */
/* ------------------------------------------------------------------ */
```

The model for LTVs begins here. The basic approach is the same as for cars, but the implementation dates and effectiveness of the various technologies may be different. Belt use is also different. In general, the notes on this section will be limited to the spots where LTVs differ from cars.

```
DATA TRK5(KEEP=CY FARSTRK VEHAGE);
SET ACCFAC1;
DO VEHAGE = -1 TO 25;
  OUTPUT;
END;
RUN;
PROC SORT DATA=TRK5; BY VEHAGE;
```

TRK6 is a matrix of LTV occupant fatalities by CY and MY.

```
DATA TRK6; MERGE TRK5 VEHAGE4; BY VEHAGE;
ORIGWT=PCTTRK*FARSTRK;
MY=CY-VEHAGE;
KEEP CY MY ORIGWT;
PROC SORT DATA=TRK6; BY CY MY;
RUN;

/* ------------------------------------------------------------------ */
/*  ALL PERMITTED COMBINATIONS OF CRASH MODE, AGE GROUP, SEAT POS     */
/*  AGE GROUPS ARE INFANT, TODDLER 1-4, ALL OTHERS 5 AND OLDER        */
/*  WEIGHT FACTORS BASED ON DISTRIBUTIONS IN 1975-80 FARS             */
/* ------------------------------------------------------------------ */
```

TRK7 is a matrix of LTV occupant fatalities by CY, MY, CRSH, SEAT2 and AGEGP. All distributions are based on 1975-80 FARS data, specifically the analysis by OLDFA14 of the file *FARS7580* generated by LS2004. There were 22,676.59 weighted cases of LTV occupant fatalities in the file analyzed by OLDFA14.

```
DATA TRK7(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP);
SET TRK6;
X=22676.59*22676.59;                                    /* FROM OLDFA14, P. 7 */
OLDWT=ORIGWT;
DO ICRSH=1 TO 5;
DO IAGESEAT=1 TO 25;                                    /* FROM OLDFA14, P. 7 */
IF ICRSH=1 THEN DO; CRSH=1; CRSHFA=10937.08; END;
  ELSE IF ICRSH=2 THEN DO; CRSH=2.1; CRSHFA=1912.215; END;
  ELSE IF ICRSH=3 THEN DO; CRSH=2.2; CRSHFA=2233.393; END;
  ELSE IF ICRSH=4 THEN DO; CRSH=3;   CRSHFA=6184.181; END;
  ELSE IF ICRSH=5 THEN DO; CRSH=4;   CRSHFA=1409.718; END;
IF IAGESEAT=1 THEN DO; SEAT2=11; AGEGP=5; ASFA=15269; END;  /* FROM OLDFA14, P. 7 */
  ELSE IF IAGESEAT= 2 THEN DO; SEAT2=12; AGEGP=0; ASFA=30.883; END;
  ELSE IF IAGESEAT= 3 THEN DO; SEAT2=12; AGEGP=1; ASFA=116.04; END;
```

```
  ELSE IF IAGESEAT= 4 THEN DO; SEAT2=12; AGEGP=5; ASFA=827.00; END;
  ELSE IF IAGESEAT= 5 THEN DO; SEAT2=13; AGEGP=0; ASFA=32.045; END;
  ELSE IF IAGESEAT= 6 THEN DO; SEAT2=13; AGEGP=1; ASFA=130.29; END;
  ELSE IF IAGESEAT= 7 THEN DO; SEAT2=13; AGEGP=5; ASFA=4389.6; END;
  ELSE IF IAGESEAT= 8 THEN DO; SEAT2=18; AGEGP=0; ASFA=7.7778; END;
  ELSE IF IAGESEAT= 9 THEN DO; SEAT2=18; AGEGP=1; ASFA=13.863; END;
  ELSE IF IAGESEAT=10 THEN DO; SEAT2=18; AGEGP=5; ASFA=36.997; END;
  ELSE IF IAGESEAT=11 THEN DO; SEAT2=21; AGEGP=0; ASFA=4.7558; END;
  ELSE IF IAGESEAT=12 THEN DO; SEAT2=21; AGEGP=1; ASFA=28.356; END;
  ELSE IF IAGESEAT=13 THEN DO; SEAT2=21; AGEGP=5; ASFA=313.38; END;
  ELSE IF IAGESEAT=14 THEN DO; SEAT2=22; AGEGP=0; ASFA=3.981; END;
  ELSE IF IAGESEAT=15 THEN DO; SEAT2=22; AGEGP=1; ASFA=17.394; END;
  ELSE IF IAGESEAT=16 THEN DO; SEAT2=22; AGEGP=5; ASFA=138.31; END;
  ELSE IF IAGESEAT=17 THEN DO; SEAT2=28; AGEGP=0; ASFA=0.0666; END;
  ELSE IF IAGESEAT=18 THEN DO; SEAT2=28; AGEGP=1; ASFA=0.5587; END;
  ELSE IF IAGESEAT=19 THEN DO; SEAT2=28; AGEGP=5; ASFA= 11.949; END;
  ELSE IF IAGESEAT=20 THEN DO; SEAT2=51; AGEGP=0; ASFA=6.0551; END;
  ELSE IF IAGESEAT=21 THEN DO; SEAT2=51; AGEGP=1; ASFA=56.304; END;
  ELSE IF IAGESEAT=22 THEN DO; SEAT2=51; AGEGP=5; ASFA=1016.3; END;
  ELSE IF IAGESEAT=23 THEN DO; SEAT2=52; AGEGP=0; ASFA=0.0641; END;
  ELSE IF IAGESEAT=24 THEN DO; SEAT2=52; AGEGP=1; ASFA=3.4122; END;
  ELSE IF IAGESEAT=25 THEN DO; SEAT2=52; AGEGP=5; ASFA= 222.19; END;
ORIGWT=OLDWT*CRSHFA*ASFA/X;
OUTPUT;
END;
END;
RUN;

/* ------------------------------------------------------------------ */
/*  ALL PERMITTED CONFIGURATIONS OF RESTRAINT USE                     */
/*                                                                    */
/*  SEPARATE ANALYSES BY SEAT POSITION, MODEL YEAR & AGE GROUP        */
/*  DEPENDING ON WHAT TYPES AND HOW MANY SYSTEMS ARE AVAILABLE        */
/*  USE RATES BASED ON 1975-80 AVGS, EXCEPT WHERE 1975 IS HIGHER      */
/*  FIRST MODERN SAFETY SEATS: CY 1967 (TODDLER) AND 1970 (INFANT)    */
/* ------------------------------------------------------------------ */
```

Similar scenarios for analysis of restraint use as in the car model, but the model years in the scenarios may differ, and so do the belt use rates.

```
DATA RES0(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP REST3)
     INF1(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP)
     TOD11(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP)
     TOD21(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP)
     FOB11(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP)
     FOB21(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP)
     FOB31(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP)
     LAP1(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP);
SET TRK7;
IF SEAT2 IN (18,28,51,52) OR (AGEGP=0 AND CY LT 1970) OR
    (SEAT2=12 AND MY LT 1968) OR (SEAT2=21 AND MY LT 1968) OR
    (SEAT2=22 AND MY LT 1968) THEN DO; REST3=0; OUTPUT RES0; END;
  ELSE IF AGEGP=0 THEN OUTPUT INF1;
  ELSE IF AGEGP=1 AND 1967 LE CY LE 1974 THEN OUTPUT TOD11;
  ELSE IF AGEGP=1 THEN OUTPUT TOD21;
  ELSE IF SEAT2 IN (11,13) AND 1969 LE MY LE 1975 THEN OUTPUT FOB11;
  ELSE IF SEAT2 IN (11,13) THEN OUTPUT FOB21;
  ELSE OUTPUT LAP1;
RUN;

DATA INF2(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP REST3);
SET INF1;
OLDWT=ORIGWT;
```

Use of infant seats among fatally injured passengers gradually increased from CY 1970, reaching 3.82 percent in 1974.

```
CRDUSE=.0382*(CY-1969)/5;                          /* FROM OLDFA14, P. 1 */
REST3=4; ORIGWT=   CRDUSE *OLDWT; OUTPUT;
REST3=0; ORIGWT=(1-CRDUSE)*OLDWT; OUTPUT;
RUN;

DATA TOD12(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP REST3);
SET TOD11;
OLDWT=ORIGWT;
```

The percentage of toddler fatalities restrained in safety seats increased from CY 1967, reaching 0.71 percent in 1974. Lap belt use by child passenger fatalities age 1-4 was 0.39 percent.

```
IF 1970 LE CY LE 1974 THEN CRDUSE=.0071*(CY-1969)/5;          /* FROM OLDFA14, P. 2 */
  ELSE IF 1967 LE CY LE 1969 THEN CRDUSE=.0071*(CY-1966)/20;
LAPUSE=.0039;
REST3=4; ORIGWT=           CRDUSE  *OLDWT; OUTPUT;
REST3=2; ORIGWT=           LAPUSE  *OLDWT; OUTPUT;
REST3=0; ORIGWT=(1-(CRDUSE+LAPUSE))*OLDWT; OUTPUT;
RUN;

DATA TOD22(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP REST3);
SET TOD21;
OLDWT=ORIGWT;
```

Before CY 1967, lap belt use by child passenger fatalities age 1-4 was 0.39 percent.

```
REST3=2; ORIGWT=.0039*OLDWT; OUTPUT;                           /* FROM OLDFA14, P. 7 */
REST3=0; ORIGWT=.9961*OLDWT; OUTPUT;
RUN;

DATA FOB12(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP REST3);
SET FOB11;
OLDWT=ORIGWT;
```

For front-outboard fatalities age 5+, lap belt use was 2.85 percent in MY 1969-75 LTVs. A few LTVs were equipped with 3-point belts; overall use among fatalities was 0.13 percent in 1969-73 and 0.7 percent in 1974-75.

```
IF 1969 LE MY LE 1973 THEN LS_USE=.0013;                       /* FROM OLDFA14, P. 18 */
  ELSE IF 1974 LE MY LE 1975 THEN LS_USE=.0070;
REST3=3; ORIGWT=           LS_USE  *OLDWT; OUTPUT;
REST3=2; ORIGWT=            .0285  *OLDWT; OUTPUT;
REST3=0; ORIGWT=(1-(LS_USE+ .0285))*OLDWT; OUTPUT;
RUN;

DATA FOB22(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP REST3);
SET FOB21;
OLDWT=ORIGWT;
```

Lap belt use by front-outboard fatalities was 2.93 percent in MY 1968 and 0.79 percent before that.

```
IF MY=1968 THEN LAPUSE=.0293;                                  /* FROM OLDFA14, P. 18 */
  ELSE LAPUSE=.0079;                                           /* FROM OLDFA14, P. 17 */
REST3=2; ORIGWT=   LAPUSE *OLDWT; OUTPUT;
REST3=0; ORIGWT=(1-LAPUSE)*OLDWT; OUTPUT;
RUN;

DATA LAP2(KEEP=CY MY ORIGWT CRSH SEAT2 AGEGP REST3);
SET LAP1;
```

```
OLDWT=ORIGWT;
```

In MY 1968-75, 1.56 percent of rear-seat fatalities and 0.45 percent of front-center fatalities were lap-belted.

```
IF SEAT2=12 THEN LAPUSE=.0045;                                    /* FROM OLDFA14, P. 19 */
  ELSE IF SEAT2=21 THEN LAPUSE=.0156;                             /* FROM OLDFA14, P. 20 */
  ELSE IF SEAT2=22 THEN LAPUSE=.0156;                             /* FROM OLDFA14, P. 20 */
REST3=2; ORIGWT=   LAPUSE *OLDWT; OUTPUT;
REST3=0; ORIGWT=(1-LAPUSE)*OLDWT; OUTPUT;
RUN;

/* ------------------------------------------------------------------ */
/*  TRK8 IS THE FULL ANALYSIS FILE                                    */
/*  EJECT2 IS PROPORTION OF FATALITIES EJECTED IN EACH CELL           */
/* ------------------------------------------------------------------ */

DATA TRK8; SET RES0 INF2 TOD12 TOD22 FOB12 FOB22 LAP2;
```

TRK8, the full analysis file, is a matrix of LTV occupant fatalities by CY, MY, CRSH, SEAT2, AGEGP and REST3.

```
WEIGHTFA=ORIGWT;
```

Proportions of unrestrained and restrained fatalities that were ejected, by crash mode.

```
IF REST3=0 THEN DO;
  IF CRSH=1 THEN EJECT2=.2331; ELSE IF CRSH=2.1 THEN EJECT2=.3664;   /* FROM OLDFA14, P. 9 */
    ELSE IF CRSH=2.2 THEN EJECT2=.3153; ELSE IF CRSH=3 THEN EJECT2=.6424;
    ELSE IF CRSH=4 THEN EJECT2=.4091; END;
ELSE DO;
  IF CRSH=1 THEN EJECT2=.1151; ELSE IF CRSH=2.1 THEN EJECT2=.2626;   /* FROM OLDFA14, P. 10 */
    ELSE IF CRSH=2.2 THEN EJECT2=.2315; ELSE IF CRSH=3 THEN EJECT2=.2483;
    ELSE IF CRSH=4 THEN EJECT2=.3106; END;
RUN;
PROC SORT DATA=TRK8; BY CY;
RUN;

/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */
/*  REPEATS THE TRK OCCUPANT ANALYSIS OF LS2004.SAS                   */
/*                                                                    */
/*  HAS TO BE SIMPLIFIED FOR 203 SINCE VIN/MAKE-MODEL UNK             */
/* ------------------------------------------------------------------ */
/* ------------------------------------------------------------------ */

DATA TRK9; SET TRK8;

/* ------------------------------------------------------------------ */
/*  ZERO BENEFITS FOR TECHNOLOGIES NOT AVAILABLE IN 1960-74           */
/* ------------------------------------------------------------------ */
```

Six of the later technologies in LS2004 did not exist in any LTV on the road in CY 1960-74.

```
PS208J=0; PV208J=0; TLS208J=0; TLV208J=0; TL208J=0;
PS108=0; PV108=0; TLS108=0; TLV108=0; TL108=0;
PS208I=0; PV208I=0; TLS208I=0; TLV208I=0; TL208I=0;
PS214A=0; PV214A=0; TLS214A=0; TLV214A=0; TL214A=0;
PS208G=0; PV208G=0; TLS208G=0; TLV208G=0; TL208G=0;
PS212=0; PV212=0; TLS212=0; TLV212=0; TL212=0;
TLS=0; TLV=0; TL=0;

/* ------------------------------------------------------------------ */
```

```
/*  213 CHILD SAFETY SEATS                                              */
/*  USE RATE WENT OVER 50% IN: 1985                                     */
/* ------------------------------------------------------------------- */

/* IDENTIFIES CHILD PASSENGERS IN SAFETY SEATS  */
  PS213=0; IF REST3=4 THEN PV213=1; ELSE PV213=0;
/* LIVES SAVED AND EJECTIONS PREVENTED BY CHILD SAFETY SEATS */
  OLDWTFA=WEIGHTFA;
  IF PS213 GT 0 OR PV213 GT 0 THEN DO;
    IF AGEGP=0 THEN E=.58; ELSE E=.59;
```

“Removing” the safety seats makes the occupants unrestrained. This is the probability that an unrestrained occupant was ejected:

```
    IF CRSH=1 THEN EJECT2=.2331; ELSE IF CRSH=2.1 THEN EJECT2=.3664;   /* FROM OLDFA14, P. 9 */
      ELSE IF CRSH=2.2 THEN EJECT2=.3153; ELSE IF CRSH=3 THEN EJECT2=.6424;
      ELSE IF CRSH=4 THEN EJECT2=.4091;
    P=PS213+PV213;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS213=S*PS213/P;
    TLV213=S*PV213/P;
    WEIGHTFA=OLDWTFA+TLS213+TLV213; END;
  ELSE DO; TLS213=0; TLV213=0; END;
  TL213=TLS213+TLV213;
  TLS=TLS+TLS213; TLV=TLV+TLV213; TL=TL+TL213;
```

```
/* ---------------------------------------------------------------- */
/*  208F 3-POINT BELTS FOR FRONT-SEAT OUTBOARD OCCUPANTS            */
/*  MEDIAN INSTALLATION YEAR: 1976                                  */
/* ---------------------------------------------------------------- */

/* IDENTIFIES FRONT-SEAT OCCUPANTS WEARING 3-POINT BELTS  */
  PS208F=0; PV208F=0;
  IF SEAT2 IN (11,13) AND REST3=3 THEN PV208F=1;
/* LIVES SAVED AND EJECTIONS PREVENTED BY FRONT-OUTBOARD 3-POINT BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208F GT 0 OR PV208F GT 0 THEN DO;
```

Unlike LS2004, which has many different effectiveness values depending on the crash mode, we will for simplicity use the overall average fatality reduction by 3-point belts in LTVs: 60 percent.

```
    E=.60;
    IF CRSH=1 THEN EJECT2=.2331; ELSE IF CRSH=2.1 THEN EJECT2=.3664;   /* FROM OLDFA14, P. 9 */
      ELSE IF CRSH=2.2 THEN EJECT2=.3153; ELSE IF CRSH=3 THEN EJECT2=.6424;
      ELSE IF CRSH=4 THEN EJECT2=.4091;
    P=PS208F+PV208F;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208F=S*PS208F/P;
    TLV208F=S*PV208F/P;
    WEIGHTFA=OLDWTFA+TLS208F+TLV208F; END;
  ELSE DO; TLS208F=0; TLV208F=0; END;
  TL208F=TLS208F+TLV208F;
  TLS=TLS+TLS208F; TLV=TLV+TLV208F; TL=TL+TL208F;

/* ---------------------------------------------------------------- */
/*  203 ENERGY-ABSORBING AND TELESCOPING STEERING ASSEMBLIES        */
/*  MEDIAN IMPLEMENTATION YEAR: EARLY 1976                          */
/* ---------------------------------------------------------------- */

/* IDENTIFIES LIGHT TRUCKS WITH ENERGY-ABSORBING STEERING ASSEMBLIES     */
  PS203=0; PV203=0;
  IF MY GE 1970 AND SEAT2=11 THEN DO;
```

LS2004 indicates that 3 percent of MY 1970 and 1971 LTVs were equipped with energy-absorbing steering assemblies. That had increased to 48 percent by MY 1974-75.

```
      IF MY=1970 THEN PV203=.03;                 /* FROM LS2004 */
        ELSE IF MY=1971 THEN PV203=.03;
        ELSE IF MY=1972 THEN PV203=.02;
        ELSE IF MY=1973 THEN PV203=.47;
        ELSE IF MY=1974 THEN PV203=.48;
        ELSE IF MY=1975 THEN PV203=.48; END;
/* LIVES SAVED IN FRONTAL IMPACTS BY INSTRUMENT PANEL IMPROVEMENTS */
  OLDWTFA=WEIGHTFA;
  IF PS203 GT 0 OR PV203 GT 0 THEN DO;
    IF CRSH=1 THEN E=.121; ELSE E=0;
    P=PS203+PV203;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS203=S*PS203/P;
    TLV203=S*PV203/P;
    WEIGHTFA=OLDWTFA+TLS203+TLV203; END;
  ELSE DO; TLS203=0; TLV203=0; END;
  TL203=TLS203+TLV203;
  TLS=TLS+TLS203; TLV=TLV+TLV203; TL=TL+TL203;

/* ---------------------------------------------------------------- */
/*  201 VOLUNTARY INSTRUMENT PANEL IMPROVEMENTS (FMVSS-201 INSPIRED)  */
/*  MEDIAN IMPLEMENTATION YEAR: 1972                                */
/* ---------------------------------------------------------------- */
```

```
/* INSTRUMENT PANELS WERE GRADUALLY IMPROVED FROM 1969 TO 1977    */
  PS201=0; PV201=0;
  IF MY GE 1969 AND SEAT2=13 THEN PV201=.125*(MY-1968);
/* LIVES SAVED IN FRONTAL IMPACTS BY INSTRUMENT PANEL IMPROVEMENTS */
  OLDWTFA=WEIGHTFA;
  IF PS201 GT 0 OR PV201 GT 0 THEN DO;
    IF CRSH=1 AND REST3 NE 2 THEN E=.159; ELSE E=0;
    P=PS201+PV201;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS201=S*PS201/P;
    TLV201=S*PV201/P;
    WEIGHTFA=OLDWTFA+TLS201+TLV201; END;
  ELSE DO; TLS201=0; TLV201=0; END;
  TL201=TLS201+TLV201;
  TLS=TLS+TLS201; TLV=TLV+TLV201; TL=TL+TL201;

/* ---------------------------------------------------------------- */
/*  105B FRONT DISC BRAKES                                          */
/*  MEDIAN INSTALLATION YEAR: 1971 (INSTALLATION COMPLETED 1977)    */
/* ---------------------------------------------------------------- */

/* IMPLEMENTATION OF FRONT DISC BRAKES */
  IF MY LE 1964 THEN DO; PS105B=0; PV105B=0; END;
    ELSE IF MY=1965 THEN DO; PS105B=0; PV105B=.02; END;
    ELSE IF MY=1966 THEN DO; PS105B=0; PV105B=.03; END;
    ELSE IF MY=1967 THEN DO; PS105B=0; PV105B=.06; END;
    ELSE IF MY=1968 THEN DO; PS105B=0; PV105B=.13; END;
    ELSE IF MY=1969 THEN DO; PS105B=0; PV105B=.28; END;
    ELSE IF MY=1970 THEN DO; PS105B=0; PV105B=.41; END;
    ELSE IF MY=1971 THEN DO; PS105B=0; PV105B=.63; END;
    ELSE IF MY=1972 THEN DO; PS105B=0; PV105B=.74; END;
    ELSE IF MY=1973 THEN DO; PS105B=0; PV105B=.86; END;
    ELSE IF MY=1974 THEN DO; PS105B=0; PV105B=.84; END;
    ELSE IF MY=1975 THEN DO; PS105B=0; PV105B=.93; END;
/* LIGHT TRUCK OCCUPANT LIVES SAVED BY FRONT DISC BRAKES */
  OLDWTFA=WEIGHTFA;
  IF PS105B GT 0 OR PV105B GT 0 THEN DO;
    E=.0017;
    P=PS105B+PV105B;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS105B=S*PS105B/P;
    TLV105B=S*PV105B/P;
    WEIGHTFA=OLDWTFA+TLS105B+TLV105B; END;
  ELSE DO; TLS105B=0; TLV105B=0; END;
  TL105B=TLS105B+TLV105B;
  TLS=TLS+TLS105B; TLV=TLV+TLV105B; TL=TL+TL105B;
```

```
/* ---------------------------------------------------------------- */
/*  208E LAP BELTS FOR BACK-SEAT CENTER OCCUPANTS                   */
/*  MEDIAN INSTALLATION YEAR: 1968                                  */
/* ---------------------------------------------------------------- */

/* IDENTIFIES BACK-CENTER-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208E=0; PV208E=0;
  IF SEAT2=22 AND REST3=2 AND AGEGP=5 THEN DO;
```

The original requirements of FMVSS 208 took effect for LTVs on July 1, 1971.

```
     IF MY GE 1972 THEN PS208E=1;
       ELSE IF MY LE 1970 THEN PV208E=1;
       ELSE IF MY=1971 AND CY=1970 THEN PV208E=1;
       ELSE IF MY=1971 THEN DO; PS208E=.17; PV208E=.83; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY BACK-CENTER-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208E GT 0 OR PV208E GT 0 THEN DO;
```

NHTSA's evaluation estimates an overall 63 percent fatality reduction by lap belts for rear-outboard occupants in LTVs. The same effectiveness is assumed for the rear-center occupant.

```
    E=.63;
    IF CRSH=1 THEN EJECT2=.2331; ELSE IF CRSH=2.1 THEN EJECT2=.3664;   /* FROM OLDFA14, P. 9 */
      ELSE IF CRSH=2.2 THEN EJECT2=.3153; ELSE IF CRSH=3 THEN EJECT2=.6424;
      ELSE IF CRSH=4 THEN EJECT2=.4091;
    P=PS208E+PV208E;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208E=S*PS208E/P;
    TLV208E=S*PV208E/P;
    WEIGHTFA=OLDWTFA+TLS208E+TLV208E; END;
  ELSE DO; TLS208E=0; TLV208E=0; END;
  TL208E=TLS208E+TLV208E;
  TLS=TLS+TLS208E; TLV=TLV+TLV208E; TL=TL+TL208E;

/* ---------------------------------------------------------------- */
/*  208D LAP BELTS FOR FRONT-SEAT CENTER OCCUPANTS                  */
/*  MEDIAN INSTALLATION YEAR: 1968                                  */
/* ---------------------------------------------------------------- */

/* IDENTIFIES FRONT-CENTER-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208D=0; PV208D=0;
  IF SEAT2=12 AND REST3=2 AND AGEGP=5 THEN DO;
     IF MY GE 1972 THEN PS208D=1;
       ELSE IF MY LE 1970 THEN PV208D=1;
       ELSE IF MY=1971 AND CY=1970 THEN PV208D=1;
       ELSE IF MY=1971 THEN DO; PS208D=.17; PV208D=.83; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY FRONT-CENTER-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208D GT 0 OR PV208D GT 0 THEN DO;
```

A double-pair comparison analysis of lap belt effectiveness for front-outboard occupants, conducted in support of this study, found that lap belts reduce fatality risk by 48 percent in LTVs. This effectiveness will also be assumed for the front-center occupant.

```
    E=.48;
    IF CRSH=1 THEN EJECT2=.2331; ELSE IF CRSH=2.1 THEN EJECT2=.3664;   /* FROM OLDFA14, P. 9 */
      ELSE IF CRSH=2.2 THEN EJECT2=.3153; ELSE IF CRSH=3 THEN EJECT2=.6424;
      ELSE IF CRSH=4 THEN EJECT2=.4091;
    P=PS208D+PV208D;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208D=S*PS208D/P;
    TLV208D=S*PV208D/P;
```

```
    WEIGHTFA=OLDWTFA+TLS208D+TLV208D; END;
  ELSE DO; TLS208D=0; TLV208D=0; END;
  TL208D=TLS208D+TLV208D;
  TLS=TLS+TLS208D; TLV=TLV+TLV208D; TL=TL+TL208D;

/* ------------------------------------------------------------------ */
/*  208C LAP BELTS FOR BACK-SEAT OUTBOARD OCCUPANTS                   */
/*  MEDIAN INSTALLATION YEAR: 1968                                    */
/* ------------------------------------------------------------------ */

/* IDENTIFIES BACK-OUTBOARD-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208C=0; PV208C=0;
  IF SEAT2=21 AND REST3=2 AND AGEGP=5 THEN DO;
     IF MY GE 1972 THEN PS208C=1;
       ELSE IF MY LE 1970 THEN PV208C=1;
       ELSE IF MY=1971 AND CY=1970 THEN PV208C=1;
       ELSE IF MY=1971 THEN DO; PS208C=.17; PV208C=.83; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY BACK-OUTBOARD-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208C GT 0 OR PV208C GT 0 THEN DO;
```

NHTSA's evaluation estimates an overall 63 percent fatality reduction by lap belts for rear-outboard occupants in LTVs.

```
    E=.63;
    IF CRSH=1 THEN EJECT2=.2331; ELSE IF CRSH=2.1 THEN EJECT2=.3664;   /* FROM OLDFA14, P. 9 */
      ELSE IF CRSH=2.2 THEN EJECT2=.3153; ELSE IF CRSH=3 THEN EJECT2=.6424;
      ELSE IF CRSH=4 THEN EJECT2=.4091;
    P=PS208C+PV208C;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208C=S*PS208C/P;
    TLV208C=S*PV208C/P;
    WEIGHTFA=OLDWTFA+TLS208C+TLV208C; END;
  ELSE DO; TLS208C=0; TLV208C=0; END;
  TL208C=TLS208C+TLV208C;
  TLS=TLS+TLS208C; TLV=TLV+TLV208C; TL=TL+TL208C;

/* ------------------------------------------------------------------ */
/*  206 DOOR LOCK IMPROVEMENTS                                        */
/*  MEDIAN INSTALLATION YEAR: 1967                                    */
/* ------------------------------------------------------------------ */

/* DOOR LOCKS IMPROVED GRADUALLY FROM 1962 TO 1972       */
  IF MY GE 1973 THEN DO; PS206=1; PV206=0; END;
    ELSE IF MY=1972 AND CY=1971 THEN DO; PS206=0; PV206=1; END;
    ELSE IF MY=1972 THEN DO; PS206=.5; PV206=.5; END;
    ELSE IF 1962 LE MY LE 1971 THEN DO; PS206=0; PV206=(MY-1961)/11; END;
    ELSE IF MY LE 1961 THEN DO; PS206=0; PV206=0; END;
/* REDUCTION IN EJECTION ROLLOVER FATALITY RISK WITH IMPROVED DOOR LOCKS */
  OLDWTFA=WEIGHTFA;
  IF (PS206 GT 0 OR PV206 GT 0) AND CRSH=3
      AND SEAT2 NE 52 AND EJECT2 NE 0 THEN DO;
    E=.098;
    P=PS206+PV206;
    REL_S=EJECT2*E*P / (1 - E*P);
    S=OLDWTFA*REL_S;
    TLS206=S*PS206/P;
    TLV206=S*PV206/P;
    WEIGHTFA=OLDWTFA+TLS206+TLV206;
    EJECT2=(EJECT2 + REL_S)/(1 + REL_S); END;
  ELSE DO; TLS206=0; TLV206=0; END;
  TL206=TLS206+TLV206;
  TLS=TLS+TLS206; TLV=TLV+TLV206; TL=TL+TL206;
```

```
/* ---------------------------------------------------------------- */
/*  105A DUAL MASTER CYLINDERS                                      */
/*  MEDIAN INSTALLATION YEAR: LATE 1966                             */
/* ---------------------------------------------------------------- */

/* IMPLEMENTATION OF DUAL MASTER CYLINDERS */
  IF MY GE 1967 THEN DO; PS105A=0; PV105A=1; END;
    ELSE IF MY LE 1961 THEN DO; PS105A=0; PV105A=0; END;
    ELSE IF MY IN (1962,1963) THEN DO; PS105A=0; PV105A=.09; END;
    ELSE IF MY IN (1964,1965) THEN DO; PS105A=0; PV105A=.07; END;
    ELSE IF MY=1966 THEN DO; PS105A=0; PV105A=.54; END;
/* LIGHT TRUCK OCCUPANT LIVES SAVED BY DUAL MASTER CYLINDERS */
  OLDWTFA=WEIGHTFA;
  IF PS105A GT 0 OR PV105A GT 0 THEN DO;
    E=.007;
    P=PS105A+PV105A;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS105A=S*PS105A/P;
    TLV105A=S*PV105A/P;
    WEIGHTFA=OLDWTFA+TLS105A+TLV105A; END;
  ELSE DO; TLS105A=0; TLV105A=0; END;
  TL105A=TLS105A+TLV105A;
  TLS=TLS+TLS105A; TLV=TLV+TLV105A; TL=TL+TL105A;

/* ---------------------------------------------------------------- */
/*  208B LAP BELT USE BY CHILDREN AGE 1-4                           */
/*  MEDIAN INSTALLATION YEAR FOR LAP BELTS USED BY CHILDREN: 1966   */
/* ---------------------------------------------------------------- */

/* IDENTIFIES CHILD PASSENGERS AGE 1-4 USING LAP BELTS */
  PS208B=0; PV208B=0;
  IF AGEGP=1 AND REST3=2 THEN DO;
     IF MY GE 1972 THEN PS208B=1;
       ELSE IF MY LE 1970 THEN PV208B=1;
       ELSE IF MY=1971 AND CY=1970 THEN PV208B=1;
       ELSE IF MY=1971 THEN DO; PS208B=.17; PV208B=.83; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY LAP BELTS (AGE 1-4) */
  OLDWTFA=WEIGHTFA;
  IF PS208B GT 0 OR PV208B GT 0 THEN DO;
```

NHTSA's evaluation estimates that lap belts reduce fatality risk by 48 percent for toddlers in LTVs.[2]

```
    E=.48;
    IF CRSH=1 THEN EJECT2=.2331; ELSE IF CRSH=2.1 THEN EJECT2=.3664;   /* FROM OLDFA14, P. 9 */
      ELSE IF CRSH=2.2 THEN EJECT2=.3153; ELSE IF CRSH=3 THEN EJECT2=.6424;
      ELSE IF CRSH=4 THEN EJECT2=.4091;
    P=PS208B+PV208B;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208B=S*PS208B/P;
    TLV208B=S*PV208B/P;
    WEIGHTFA=OLDWTFA+TLS208B+TLV208B; END;
  ELSE DO; TLS208B=0; TLV208B=0; END;
  TL208B=TLS208B+TLV208B;
  TLS=TLS+TLS208B; TLV=TLV+TLV208B; TL=TL+TL208B;

/* ---------------------------------------------------------------- */
/*  208A LAP BELTS FOR FRONT-SEAT OUTBOARD OCCUPANTS                */
/*  MEDIAN INSTALLATION YEAR: 1964                                  */
/* ---------------------------------------------------------------- */
```

[2] This evaluation is discussed in the "Child Safety Seats" section of the FMVSS 213 chapter of Part 1, not the FMVSS 208 chapter.

```
/* IDENTIFIES FRONT-OUTBOARD-SEAT OCCUPANTS WEARING LAP BELTS  */
  PS208A=0; PV208A=0;
  IF SEAT2 IN (11,13) AND REST3=2 AND AGEGP=5 THEN DO;
     IF MY GE 1972 THEN PS208A=1;
       ELSE IF MY LE 1970 THEN PV208A=1;
       ELSE IF MY=1971 AND CY=1970 THEN PV208A=1;
       ELSE IF MY=1971 THEN DO; PS208A=.17; PV208A=.83; END; END;
/* LIVES SAVED AND EJECTIONS PREVENTED BY FRONT-OUTBOARD-SEAT LAP BELTS */
  OLDWTFA=WEIGHTFA;
  IF PS208A GT 0 OR PV208A GT 0 THEN DO;
```

A double-pair comparison analysis of lap belt effectiveness for front-outboard occupants, conducted in support of this study, found that lap belts reduce fatality risk by 48 percent in LTVs.

```
    E=.48;
    IF CRSH=1 THEN EJECT2=.2331; ELSE IF CRSH=2.1 THEN EJECT2=.3664;   /* FROM OLDFA14, P. 9 */
      ELSE IF CRSH=2.2 THEN EJECT2=.3153; ELSE IF CRSH=3 THEN EJECT2=.6424;
      ELSE IF CRSH=4 THEN EJECT2=.4091;
    P=PS208A+PV208A;
    S=OLDWTFA*E*P / (1 - E*P);
    TLS208A=S*PS208A/P;
    TLV208A=S*PV208A/P;
    WEIGHTFA=OLDWTFA+TLS208A+TLV208A; END;
  ELSE DO; TLS208A=0; TLV208A=0; END;
  TL208A=TLS208A+TLV208A;
  TLS=TLS+TLS208A; TLV=TLV+TLV208A; TL=TL+TL208A;
RUN;
```

That concludes the model for LTVs. It has estimated, on a cell-by-cell basis, by how much fatalities would increase if all the safety technologies were "removed." The last steps are to tally up the lives saved over all the cells, by calendar year, and print the results.

```
PROC MEANS SUM NOPRINT DATA=TRK9; BY CY;
  VAR ORIGWT WEIGHTFA
    TLV208J TLS208J TL208J
    TLV108 TLS108 TL108
    TLV208I TLS208I TL208I
    TLV214A TLS214A TL214A
    TLV208G TLS208G TL208G
    TLV213 TLS213 TL213
    TLV212 TLS212 TL212
    TLV208F TLS208F TL208F
    TLV203 TLS203 TL203
    TLV201 TLS201 TL201
    TLV105B TLS105B TL105B
    TLV208E TLS208E TL208E
    TLV208D TLS208D TL208D
    TLV208C TLS208C TL208C
    TLV206 TLS206 TL206
    TLV105A TLS105A TL105A
    TLV208B TLS208B TL208B
    TLV208A TLS208A TL208A
    TLV TLS TL;
  OUTPUT OUT=TRK10
    SUM=T_ORIGWT T_WTFA TLV108 TLS108 TL108
    TLV208J TLS208J TL208J
    TLV208I TLS208I TL208I
    TLV214A TLS214A TL214A
    TLV208G TLS208G TL208G
    TLV213 TLS213 TL213
    TLV212 TLS212 TL212
    TLV208F TLS208F TL208F
    TLV203 TLS203 TL203
    TLV201 TLS201 TL201
```

```
    TLV105B TLS105B TL105B
    TLV208E TLS208E TL208E
    TLV208D TLS208D TL208D
    TLV208C TLS208C TL208C
    TLV206 TLS206 TL206
    TLV105A TLS105A TL105A
    TLV208B TLS208B TL208B
    TLV208A TLS208A TL208A
    TLV TLS TL;

PROC PRINT DATA=TRK10;
  FORMAT TLV213 TLS213 TL213 TLV212 TLS212 TL212 TLV208F TLS208F TL208F 9.0;
  ID CY; VAR TLV213 TLS213 TL213 TLV212 TLS212 TL212 TLV208F TLS208F TL208F;
  SUM TLV213 TLS213 TL213 TLV212 TLS212 TL212 TLV208F TLS208F TL208F;
TITLE1 'LIGHT TRUCK OCCUPANT LIVES SAVED BY CHILD SAFETY SEATS, ADHESIVE WINDSHIELD BONDING, AND
FRONT-SEAT 3-POINT BELTS, 1960-74';
TITLE2 ' ';
TITLE3 '...213  = CHILD SAFETY SEATS (USE EXCEEDED 50% IN 1985, FMVSS EFFECTIVE 4/1/71, STATE LAWS
1978-85)';
TITLE4 '...212  = ADHESIVE WINDSHIELD BONDING (MEDIAN INSTALLATION YEAR 1979, FMVSS EFFECTIVE
9/1/78)';
TITLE5 '...208F = 3-POINT BELTS FOR FRONT-SEAT OCCUPANTS (MEDIAN INSTALLATION YEAR 1976, FMVSS
EFFECTIVE 9/1/76)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, LIGHT TRUCKS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';
PROC PRINT DATA=TRK10;
  FORMAT TLV203 TLS203 TL203 TLV201 TL201 TLV105B TLS105B TL105B 9.0;
  ID CY; VAR TLV203 TLS203 TL203 TLV201 TL201 TLV105B TLS105B TL105B;
  SUM TLV203 TLS203 TL203 TLV201 TL201 TLV105B TLS105B TL105B;
TITLE1 'LIGHT TRUCK OCCUPANT LIVES SAVED BY EA STEERING ASSEMBLIES, SAFER INSTRUMENT PANELS, AND
FRONT DISC BRAKES, 1960-74';
TITLE2 ' ';
TITLE3 '...203  = ENERGY-ABSORBING STEERING ASSEMBLIES (MEDIAN IMPLEMENTATION YEAR EARLY 1976,
FMVSS EFFECTIVE 9/1/81)';
TITLE4 '...201  = VOLUNTARY INSTRUMENT PANEL IMPROVEMENTS (MEDIAN IMPLEMENTATION YEAR 1972, FMVSS
EFFECTIVE 9/1/81)';
TITLE5 '...105B = FRONT DISC BRAKES (MEDIAN INSTALLATION YEAR 1971, FMVSS EFFECTIVE 9/1/83)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, LIGHT TRUCKS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=TRK10;
  FORMAT TLV208E TLS208E TL208E TLV208D TLS208D TL208D TLV208C TLS208C TL208C 9.0;
  ID CY; VAR TLV208E TLS208E TL208E TLV208D TLS208D TL208D TLV208C TLS208C TL208C;
  SUM TLV208E TLS208E TL208E TLV208D TLS208D TL208D TLV208C TLS208C TL208C;
TITLE1 'LIGHT TRUCK OCCUPANT LIVES SAVED BY BACK-CENTER LAP BELTS, FRONT-CENTER LAP BELTS, AND
BACK-OUTBOARD LAP BELTS, 1960-74';
TITLE2 ' ';
TITLE3 '...208E = LAP BELTS FOR BACK-CENTER OCCUPANTS (MEDIAN INSTALLATION YEAR 1968, FMVSS
EFFECTIVE 7/1/71)';
TITLE4 '...208D = LAP BELTS FOR FRONT-CENTER OCCUPANTS (MEDIAN INSTALLATION YEAR 1968, FMVSS
EFFECTIVE 7/1/71)';
TITLE5 '...208C = LAP BELTS FOR BACK-OUTBOARD OCCUPANTS (MEDIAN INSTALLATION YEAR 1968, FMVSS
EFFECTIVE 7/1/71)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, LIGHT TRUCKS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=TRK10;
  FORMAT TLV206 TLS206 TL206 TLV105A TLS105A TL105A TLV208B TLS208B TL208B 9.0;
  ID CY; VAR TLV206 TLS206 TL206 TLV105A TLS105A TL105A TLV208B TLS208B TL208B;
  SUM TLV206 TLS206 TL206 TLV105A TLS105A TL105A TLV208B TLS208B TL208B;
TITLE1 'LIGHT TRUCK OCCUPANT LIVES SAVED BY IMPROVED DOOR LOCKS, DUAL MASTER CYLINDERS, AND LAP
BELTS FOR CHILDREN AGE 1-4, 1960-74';
TITLE2 ' ';
TITLE3 '...206  = IMPROVED DOOR LOCKS (MEDIAN INSTALLATION YEAR 1967, FMVSS EFFECTIVE 1/1/72)';
```

```
TITLE4 '...105A = DUAL MASTER CYLINDERS (MEDIAN INSTALLATION YEAR LATE 1966, FMVSS EFFECTIVE
9/1/83)';
TITLE5 '...208B = LAP BELT USE BY CHILDREN AGE 1-4 (MEDIAN INSTALLATION YEAR 1966, FMVSS EFFECTIVE
7/1/71)';
TITLE6 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE7 '...S = STANDARD INSTALLATIONS, LIGHT TRUCKS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

PROC PRINT DATA=TRK10;
  FORMAT TLV208A TLS208A TL208A 9.0;
  ID CY; VAR TLV208A TLS208A TL208A;
  SUM TLV208A TLS208A TL208A;
TITLE1 'LIGHT TRUCK OCCUPANT LIVES SAVED BY FRONT-OUTBOARD LAP BELTS, 1960-74';
TITLE2 ' ';
TITLE3 '...208A = LAP BELTS FOR FRONT-OUTBOARD OCCUPANTS (MEDIAN INSTALLATION YEAR 1964, FMVSS
EFFECTIVE 7/1/71)';
TITLE4 '...V = VOLUNTARY INSTALLATIONS, BEFORE FMVSS EFFECTIVE DATE';
TITLE5 '...S = STANDARD INSTALLATIONS, LIGHT TRUCKS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';

DATA TRK11; SET TRK10;
PCT_SAVE=100*TL/T_WTFA;
PROC PRINT DATA=TRK11;
  FORMAT T_ORIGWT T_WTFA TLV TLS TL 9.0 PCT_SAVE 6.2;
  ID CY; VAR T_ORIGWT T_WTFA TLV TLS TL PCT_SAVE;
  SUM T_ORIGWT T_WTFA TLV TLS TL;
TITLE1 'OVERALL LIGHT TRUCK OCCUPANT LIVES SAVED BY VEHICLE SAFETY STANDARDS AND TECHNOLOGIES,
1960-74';
TITLE2 ' ';
TITLE3 'T_ORIGWT = ACTUAL LIGHT TRUCK OCCUPANT FATALITIES';
TITLE4 'T_WTFA = FATALITIES THAT WOULD HAVE OCCURRED WITHOUT ANY VEHICLE SAFETY IMPROVEMENTS';
TITLE5 'TLV = OVERALL LIVES SAVED BY VOLUNTARY IMPROVEMENTS, BEFORE FMVSS EFFECTIVE DATE';
TITLE6 'TLS = OVERALL LIVES SAVED IN LIGHT TRUCKS BUILT ON OR AFTER FMVSS EFFECTIVE DATE';
TITLE7 'TL = OVERALL LIVES SAVED BY VEHICLE SAFETY IMPROVEMENTS (TLV + TLS)';
TITLE8 'PCT_SAVE = PERCENT OF WOULD-HAVE-BEEN FATALITIES SAVED BY SAFETY STANDARDS AND
TECHNOLOGIES';
RUN;
```

APPENDIX B: SUMMARIES OF PUBLISHED EVALUATION REPORTS

A systematic program to evaluate the effectiveness of the Federal Motor Vehicle Safety Standards (FMVSS) was initiated in 1975, when NHTSA was just beginning to establish its own crash databases. The first "preliminary" evaluation of a standard was published in 1979 (side door strength) and the first "final" evaluations in 1981 (energy-absorbing steering assemblies, bumpers). Since 1979, 48 comprehensive evaluations of regulations, safety programs, consumer information programs, or safety technologies have been published. Here is a list of the 48 studies including summaries of principal findings [except where findings were superseded in a follow-up evaluation]:

2004

Preliminary Results Analyzing the Effectiveness of Electronic Stability Control (ESC) Systems (NHTSA Publication DOT HS 809 790)

ESC systems detect when a vehicle is about to go out of control and automatically intervene by applying the brakes to individual wheels and possibly reducing engine torque to help the driver stay on course. Preliminary analyses found statistically significant crash reductions in certain luxury passenger cars and SUVs currently equipped with ESC systems. Single vehicle crashes were reduced by 35 percent in passenger cars and by 67 percent in SUVs. Fatal single vehicle crashes were reduced by 30 percent in cars and by 63 percent in SUVs.

Evaluation of Rear Window Defrosting and Defogging Systems (NHTSA Publication DOT HS 809 724)

Almost all new cars, minivans and SUVs have rear window defoggers, even though Federal standards do not require them. Analyses of crashes where drivers were backing up or changing lanes during rain or snow, early morning hours, or in the winter did not show a statistically significant reduction with defoggers. Nevertheless, NHTSA would expect consumers to continue wanting rear window defoggers for their vehicles because they conveniently clear condensation, frost, ice, and/or snow from the back window.

Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors (NHTSA Publication DOT HS 809 719)

Light trucks (pickup trucks, vans, and sport utility vehicles) were required to meet a crush resistance standard for side doors beginning September 1, 1993. Side door beams were installed to reduce the velocity and depth of door intrusion in side impact crashes. The beams are estimated to reduce fatalities by 19 percent in single vehicle side impacts. When all light trucks on the road have head restraints, they will save an estimated 151 lives per year. Little or no fatality reduction was found in multivehicle crashes.

2003

Results of the Survey on the Use of Passenger Air Bag On-Off Switches (NHTSA Publication DOT HS 809 689)

On-off switches allow drivers to temporarily deactivate air bags when children must ride in the front seat of pickup trucks and other vehicles that cannot accommodate rear-facing child safety seats in the back seat. NHTSA recommends that passenger air bag be turned off when a child age 12 or younger must ride in the front seat, and turned on if all front-seat occupants are age 13 or older. In a 2000 survey, switches were left on for 14 percent of infants and 26 percent of child passengers age 1-6, but turned off for 17 percent of the adult passengers.

Vehicle Weight, Fatality Risk and Crash Compatibility of Model Year 1991-99 Passenger Cars and Light Trucks (NHTSA Publication DOT HS 809 662)

There is little association between vehicle weight and fatal-crash rates in the heavier light trucks and vans. However, in other groups of model year 1991-99 vehicles, fatality rates increased as weights decreased. Pickup trucks and SUVs of these model years had, on the average, higher fatality rates than passenger cars or minivans of comparable weight. Model year 1991-99 light trucks and vans, especially those with high, rigid frontal structures, were more aggressive than cars when they struck other vehicles.

NCAP Test Improvements with Pretensioners and Load Limiters (NHTSA Publication DOT HS 809 562)

Safety belt pretensioners pull belts snug as a crash begins. Load limiters allow belts to yield slightly during a crash to reduce the force on the wearer's chest. In New Car Assessment Program (NCAP) frontal barrier crashes at 35 mph, the combination of pretensioners and load limiters reduced average Head Injury Criterion (HIC) by 232, chest acceleration by 6.6 g's and chest deflection by 10.6 mm, for driver and right front passenger dummies, relative to cars and light trucks of the same make-models without these features.

2002

Evaluation of Child Safety Seat Registration (NHTSA Publication DOT HS 809 518)

Since March 1993, manufacturers of child safety seats have been required to provide a postage-paid registration form with each new child safety seat. Seat registration has increased from 3 percent prior to 1993 to 27 percent in 1996-2000. The repair rate for recalled child safety seats increased from 13.8 percent prior to 1993 to 21.5 percent.

Preliminary Report: The Incidence Rate of Odometer Fraud (NHTSA Publication DOT HS 809 441)

There are an estimated 452,000 cases of odometer rollback per year in the United States. The difference between the inflated prices that consumers paid for rolled-back vehicles and the prices they would have been willing to pay if they had known the true mileage average $2,336 per case of odometer rollback, amounting to $1,056 million per year in the United States.

2001

The Effectiveness of Head Restraints in Light Trucks (NHTSA Publication DOT HS 809 247)

The purpose of a head restraint is to prevent whiplash injuries in rear-impact crashes. Head restraints reduce overall injury risk in light trucks in rear impacts by a statistically significant 6 percent. When all light trucks on the road have head restraints, they will be preventing approximately 15,000 nonfatal injuries per year. (See also the 1982 evaluation of head restraints in passenger cars.)

The Effectiveness of Retroreflective Tape on Heavy Trailers (NHTSA Publication DOT HS 809 222)

Retroreflective tape enhances the visibility of heavy trailers in the dark. The tape reduces side and rear impacts by other vehicles into trailers by 29 percent in dark conditions (including dark-not-lighted, dark-lighted, dawn and dusk). In dark-not-lighted conditions, the tape reduces side and rear impacts by 41 percent. When all heavy trailers have the tape, it will prevent an estimated 191-350 fatalities, 3,100-5,000 injuries and 7,800 crashes per year.

Evaluation of the American Automobile Labeling Act (NHTSA Publication DOT HS 809 208)

In a survey of 646 recent or imminent new-vehicle buyers, over 75 percent were unaware of the existence of automobile parts content labels. Among those who had read the labels, many said they used the country-of-assembly information, but none said they used the numerical U.S./Canadian parts content score. Overall U.S./Canadian parts content in new cars and light trucks dropped from an average of 70 percent in model year 1995 to 67.6 percent in 1998. However, it increased from 47 to 59 percent in transplants while dropping from 89 to 84 percent in Big 3 vehicles: trends undoubtedly influenced by the 1995 U.S.-Japan Agreement on Autos and Auto Parts and the North American Free Trade Agreement (NAFTA).

2000

Fatality Reduction by Safety Belts for Front-Seat Occupants of Cars and Light Trucks: Updated and Expanded Estimates Based on 1986-99 FARS Data (NHTSA Publication DOT HS 809 199)

Manual three-point belts reduce fatality risk, relative to the unrestrained front-seat occupant, by 45 percent in passenger cars and by 60 percent in pickup trucks, vans and sport utility vehicles. The analyses reconfirm the agency's earlier (1984-89) estimates of fatality reduction.

1999

Evaluation of FMVSS 214 - Side Impact Protection: Dynamic Performance Requirement; Phase 1: Correlation of TTI(d) with Fatality Risk in Actual Side Impact Collisions of Model Year 1981-1993 Passenger Cars (NHTSA Publication DOT HS 809 004)

The test injury criterion TTI(d) has a statistically significant association with fatality risk in actual side-impact crashes on the highway. In model year 1981-93 cars, make-models with low TTI(d) on the FMVSS 214 test tend to have low fatality risk. The relationship is stronger in 2-door than 4-door cars. Reducing TTI(d) by one unit is associated with an estimated 0.927 percent reduction of fatality risk in side impacts of 2-door cars. The association in the corresponding analysis of 4-door cars was not statistically significant.

Effectiveness of Lap/Shoulder Belts in the Back Outboard Seating Positions (NHTSA Publication DOT HS 808 945)

Lap/shoulder belts reduce fatality risk by 44 percent relative to unrestrained back-seat occupants of passenger cars, and by 15 percent relative to lap-belted occupants. Lap belts reduce fatality risk by 32 percent relative to unrestrained occupants. Lap/shoulder belts are effective in all crashes, but lap belts only in nonfrontal crashes. Lap-belted occupants have substantially higher abdominal-injury risk than unrestrained back-seat occupants in frontal crashes, but lap/shoulder belts reduce abdominal injuries by 52 percent and head injuries by 47 percent relative to lap belts.

1998

Highway Safety Assessment: A Summary of Findings in Ten States (NHTSA Publication DOT HS 808 796)

Assessment of 1980-1993 safety programs in ten States showed that Federal grants and technology were used to address safety priorities as intended by Congress. Federal grants, amounting to less than two percent of total safety spending by States and communities, have acted as seed money to resolve important highway safety problems. Programs started with Federal funds were often extended or replicated elsewhere with State funds. Occupant protection programs, however, remain heavily dependent on Federal funds.

Auto Theft and Recovery - Effects of the Anti Car Theft Act of 1992 and the Motor Vehicle Theft Law Enforcement Act of 1984 - Report to the Congress (NHTSA Publication DOT HS 808 761)

Theft rates, which had increased during the 1980's, declined from 714 per million in 1990 to 597 in 1995. Parts marking and factory-installed anti-theft devices have had beneficial and complementary effects on auto thefts and/or recoveries. The Acts have given law enforcement tools to deter thefts, trace stolen vehicles and parts, and apprehend and convict thieves.

The Long-Term Effectiveness of Center High Mounted Stop Lamps in Passenger Cars and Light Trucks (NHTSA Publication DOT HS 808 696)

Throughout 1989-95, cars equipped with Center High Mounted Stop Lamps were 4.3 percent less likely to be struck in the rear than cars without the lamps. (In 1987, when the lamps were first introduced, the reduction was 8.5 percent.) The effectiveness of CHMSL in light trucks is about the same as in cars. At the 1989-95 effectiveness level, when all cars and light trucks on the road have the lamps, they would prevent 194,000-239,000 crashes, 58,000-70,000 nonfatal injuries and $655 million in property damage per year.

1997

Relationship of Vehicle Weight to Fatality and Injury Risk in Model Year 1985-93 Passenger Cars and Light Trucks (NHTSA Publication DOT HS 808 569); ***Relationships between Vehicle Size and Fatality Risk in Model Year 1985-93 Passenger Cars and Light Trucks*** (NHTSA Publication DOT HS 808 570)

[Findings have been superseded by the 2003 evaluation - see above.]

1996

Fatality Reduction by Air Bags: Analyses of Accident Data through Early 1996 (NHTSA Publication DOT HS 808 470)

Driver air bags reduce overall fatality risk by an estimated 11 percent in passenger cars and light trucks (essentially unchanged from the 1994 and 1992 NHTSA analyses). Passenger air bags are beneficial for right-front passengers age 13 or older. Air bags provide a life-saving benefit for belted as well as unbelted drivers. The fatality risk for child passengers age 0-12 in cars with passenger air bags is currently higher than in cars without them. Current air bags are significantly less effective for drivers age 70 or older than for younger drivers.

1995

Preliminary Evaluation of the Effectiveness of Antilock Brake Systems for Passenger Cars (NHTSA Publication DOT HS 808 206)

ABS significantly reduced multivehicle crashes on wet roads: fatal crashes by 24 percent, and nonfatal crashes by 14 percent. Fatal collisions with pedestrians and bicyclists were down a significant 27 percent. However, these reductions were offset by statistically significant increases in single vehicle, run-off-road crashes (rollovers or impacts with fixed objects). Fatal run-off-road crashes were up by 28 percent, and nonfatal crashes by 19 percent in the ABS-equipped cars, as compared to similar cars without ABS.

1994

Fatality Reduction by Automatic Occupant Protection in the United States (Proceedings of the 14th Conference on Enhanced Safety of Vehicles)

The fatality risk of front-outboard occupants in cars with motorized 2-point belts (without disconnect) is 6 percent lower than in cars with manual belts; the risk in cars with non-motorized 3-point belts is the same as in cars with manual belts. [This report's findings on air bags have been superseded by the 1996 evaluation - see above.]

An Evaluation of the Effects of Glass-Plastic Windshield Glazing in Passenger Cars (NHTSA Publication DOT HS 808 062)

Following an amendment to the glazing standard (FMVSS 205) in 1983, two manufacturers equipped some of their cars with glass-plastic windshields. Crash data indicate the injury reduction potential of these windshields is less than predicted. Fleet and warranty data show that durability problems are greater than anticipated. While glass-plastic windshields add $65 to the cost of a new car, their replacement costs are estimated to exceed $1,700.

Correlation of NCAP Performance with Fatality Risk in Actual Head-On Collisions (NHTSA Publication DOT HS 808 061)

There is a statistically significant correlation between the performance of passenger cars on the NCAP test and the fatality risk of belted drivers in actual head-on collisions. In a head-on collision between a car with "good" NCAP performance and a car of equal mass with "poor" performance, the driver of the "good" car has, on the average, about 15-25 percent lower fatality risk. The steady improvement in NCAP scores during 1979-91 was paralleled by a 20-25 percent reduction of fatality risk for belted drivers in actual head-on collisions.

1993

Preliminary Evaluation of the Effectiveness of Rear-Wheel Antilock Brake Systems for Light Trucks (Submitted to NHTSA Docket No. 70-27-GR-026)

Rear-wheel ABS significantly reduced the risk of nonfatal run-off-road crashes in light trucks: rollovers by about 30-40 percent, side impacts with fixed objects by 15-30 percent and frontal impacts with fixed objects by 5-20 percent. The reductions mostly did not carry over to fatal run-off-road crashes. Collisions with pedestrians and bicyclists were reduced by 5-15 percent. Involvements in multivehicle crashes were not reduced, and may even have increased with rear-wheel ABS.

1992

Evaluation of the Effectiveness of Occupant Protection - Federal Motor Vehicle Safety FMVSS 208 - Interim Report (NHTSA Publication DOT HS 807 843)

Air bags and automatic belts have significantly reduced the risk of nonfatal injury and occupant ejection. [This report's findings on fatality reduction for air bags have been superseded by the 1996 evaluation; for automatic belts - by the 1994 evaluation.]

An Evaluation of the Uniform Tire Quality Grading Standards and Other Tire Labeling Requirements (NHTSA Publication DOT HS 807 805)

Consumers and tire dealers were surveyed about their knowledge and utilization of tire quality grades and other tire information supplied in response to Federal regulations. The ratings for treadwear were viewed as "important" by 29 percent of consumers who had recently purchased tires, and the ratings for traction, by 27 percent. The majority of consumers are not aware that these ratings are printed on the tires.

1991

Auto Theft and Recovery - Effects of the Motor Vehicle Theft Law Enforcement Act of 1984 - Report to the Congress (NHTSA Publication DOT HS 807 703)

[Findings have been superseded by the 1998 evaluation - see above.]

Effect of Car Size on Fatality and Injury Risk

[Findings have been superseded by the 2003 evaluation - see above.]

1990

Motor Vehicle Fires in Traffic Crashes and the Effects of the Fuel System Integrity Standard (NHTSA Publication DOT HS 807 675)

Modifications to fuel systems in response to FMVSS 301 reduced the frequency of fires in nonfatal crashes of passenger cars by an estimated 14 percent; fatalities in cars and light trucks, however, were not affected. During 1975-88, the number of fire-related fatalities has increased from 1,300 to 1,800, primarily due to an aging vehicle fleet.

1989

An Evaluation of Door Locks and Roof Crush Resistance of Passenger Cars - Federal Motor Vehicle Safety Standards 206 and 216 (NHTSA Publication DOT HS 807 489)

Door latch improvements implemented during 1963-68 (preceding or responding to FMVSS 206) save an estimated 400 lives per year, reducing the risk of ejection in rollover crashes by 15 percent. The shift from hardtops to pillared cars with stronger roof support, in response to FMVSS 216, saves an estimated 110 lives per year.

An Evaluation of Center High Mounted Stop Lamps Based on 1987 Data (NHTSA Publication DOT HS 807 442)

[Findings have been superseded by the 1998 evaluation - see above.]

1988

An Evaluation of Occupant Protection in Frontal Interior Impact for Unrestrained Front Seat Occupants of Cars and Light Trucks (NHTSA Publication DOT HS 807 203)

During the 1960's and early 1970's, the manufacturers modified instrument panels of cars and light trucks, installing padding, reducing the rigidity of structures and extending the panel downward and toward the passenger. The improvements reduced fatality risk and serious injury risk by nearly 25 percent for unrestrained right front passengers of cars in frontal crashes, saving up to 700 lives per year.

1987

An Evaluation of the Bumper Standard - As Modified in 1982 (NHTSA Publication DOT HS 807 072)

To reduce regulatory burden on manufacturers, damage resistance requirements for bumpers were relaxed in model year 1983: the impact test speed was lowered from 5 to 2.5 mph. The net costs to consumers did not significantly change. A small increase in the repair cost over the lifetime of the car is offset by a reduction in the initial cost of the lighter bumpers. (See also the 1981 evaluation of bumpers.)

A Preliminary Evaluation of Seat Back Locks for Two-Door Passenger Cars with Folding Front Seatbacks (NHTSA Publication DOT HS 807 067)

FMVSS 207 requires a locking device for front seats with folding seatbacks, designed to limit the forward motion of the seatback in a collision. These locks or other seat components often separate at moderate crash speeds when they are impacted by back-seat occupants. No statistically significant injury or fatality reductions were found for seat back locks in any of the crash data files or in sled tests.

Fatality and Injury Reducing Effectiveness of Lap Belts for Back Seat Occupants (SAE Paper 870486)

[Findings have been superseded by the 1999 evaluation - see above.]

The Effectiveness of Center High Mounted Stop Lamps - A Preliminary Evaluation (NHTSA Publication DOT HS 807 076)

[Findings have been superseded by the 1998 evaluation - see above.]

1986

Fuel Economy and Annual Travel for Passenger Cars and Light Trucks: National On-Road Survey (NHTSA Publication DOT HS 806 971)

The actual fuel economy of model year 1978-81 vehicles was measured by a national survey in which drivers maintained log books of mileage and fuel purchases. On-road fuel economy of cars increased by 41 percent during model years 1977-81; the fuel economy of light trucks increased by 17-26 percent. However, the actual on-road fuel economy is consistently 15-20 percent below laboratory (EPA) ratings.

An Evaluation of Child Passenger Safety: The Effectiveness and Benefits of Safety Seats (NHTSA Publication DOT HS 806 890)

A correctly used safety seat reduces fatality risk by an estimated 71 percent and serious injury risk by 67 percent. But misuse can partially or completely nullify this effect. In 1984, when 39 percent of safety seats were correctly used and 61 percent were misused, the average overall fatality reduction for safety seats (correct users plus misusers) was 46 percent. In all, 192 children were saved by safety seats and lap belts in 1984.

1985

An Evaluation of Windshield Glazing and Installation Methods for Passenger Cars (NHTSA Publication DOT HS 806 693)

The High Penetration Resistant windshield doubled the impact velocity needed for the occupant's head to penetrate the windshield, reducing serious facial lacerations by 74 percent, preventing 39,000 serious lacerations and 8,000 facial fractures per year. Adhesive bonding of the windshield halved the incidence of bond separation and occupant ejection through the windshield portal in crashes, saving 105 lives per year.

1984

Effectiveness - Manual Lap and Lap/Shoulder Belts (Chapter IV-A of "Final Regulatory Impact Analysis - Amendment to Federal Motor Vehicle Safety Standard 208 - Passenger Car Front Seat Occupant Protection," NHTSA Publication DOT HS 806 572)

Manual lap-shoulder belts are estimated to reduce the fatality risk of drivers and right-front passengers by 40-50 percent [reconfirmed and superseded by the 2000 evaluation - see above], and serious injury risk by 45-55 percent, relative to an unrestrained occupant. The manual lap belt, alone, is estimated to reduce fatality risk by 30-40 percent and serious injury risk by 25-35 percent.

1983

An Evaluation of Side Marker Lamps for Cars, Trucks and Buses (NHTSA Publication DOT HS 806 430)

Side marker lamps were installed in response to FMVSS 108 to enable a driver to see another vehicle that is approaching at an angle at night. The lamps reduced nonfatal nighttime angle collisions by 16 percent, preventing 106,000 crashes, 93,000 injuries and $347 million in property damage per year. The lamps have not been effective in reducing fatalities.

A Preliminary Evaluation of Two Braking Improvements for Passenger Cars - Dual Master Cylinders and Front Disc Brakes (NHTSA Publication DOT HS 806 359)

Dual master cylinders, by providing a backup braking system in case of certain types of brake failure, prevent 40,000 crashes, 260 fatalities, 24,000 injuries and $132 million in property damage per year. Front disc brakes, which improve vehicle handling under various braking conditions, are estimated to prevent 10,000 crashes, 64 fatalities, 5,700 injuries and $32 million in property damage per year.

Evaluation of Federal Motor Vehicle Safety Standard 301-75, Fuel System Integrity: Passenger Cars (NHTSA Publication DOT HS 806 335)

[Findings have been superseded by the 1990 evaluation - see above.]

1982

An Evaluation of Side Structure Improvements in Response to Federal Motor Vehicle Safety Standard 214 (NHTSA Publication DOT HS 806 314)

Side door beams were installed in passenger cars to reduce the velocity and depth of door intrusion in side impact crashes. The beams are especially effective in side impacts with fixed objects, preventing 480 fatalities and 4,500 hospitalizations per year. In vehicle-to-vehicle side impacts, they prevent 4,900 nonfatal hospitalizations per year, but have not reduced fatality risk.

An Evaluation of Head Restraints - Federal Motor Vehicle Safety Standard 202 (NHTSA Publication DOT HS 806 108)

The purpose of a head restraint is to prevent whiplash injury in rear-impact crashes. There are integral (fixed) and adjustable head restraints; 75 percent of adjustable restraints are left in the "down" position by occupants. In 1982, integral head restraints reduced injury risk in rear impacts by 17 percent; adjustable restraints by 10 percent. The 1982 mix of head restraints prevented 64,000 whiplash injuries per year. [Subsequently, manufacturers have enlarged adjustable restraints to provide better protection, even in the "down" position. See also the 2001 evaluation of head restraints in light trucks.]

1981

An Evaluation of the Bumper Standard (NHTSA Publication DOT HS 805 866)

In order to reduce car repair costs for consumers, damage resistance tests were established for bumpers in model year 1973 and upgraded in 1974 and 1979. The bumper standards did not significantly change net costs for consumers: the savings in repair costs over the lifetime of the car are almost equal to the increase in the initial cost of the bumpers. (See also the 1987 evaluation of bumpers.)

An Evaluation of Federal Motor Vehicle Safety Standards for Passenger Car Steering Assemblies: Standard 203 - Impact Protection for the Driver; Standard 204 - Rearward Column Displacement (NHTSA Publication DOT HS 805 705)

Energy-absorbing, telescoping steering columns reduced the risk of serious injury due to steering-assembly contact by 38 percent. Rearward column displacement was reduced by 81 percent. The standards prevent 1,300 fatalities and 23,000 hospitalizations per year. The performance of energy-absorbing steering assemblies is degraded under nonaxial impact conditions.

1979

An Evaluation of Standard 214 (NHTSA Publication DOT HS 804 858)

[Findings have been superseded by the 1982 evaluation - see above.]