ACKNOWLEDGMENT

The findings in this report are a result of a study performed under a federal grant received by the Traffic Improvement Association of Oakland County, Michigan, in cooperation with the Michigan Office of Highway Safety Planning and the Federal Highway Administration, U.S. Department of Transportation. We wish to express our gratitude to the sponsoring agencies. The opinions, findings, and conclusions in this publication are ours and not necessarily those of the state of Michigan or the U.S. Department of Transportation, Federal Highway Administration.

REFERENCES

1. Transportation Safety Information Report. U.S. Department of Transportation, 1975, pp. 9-12.
2. Roy Jorgenson Associates. Methods for Evaluating Highway Safety Improvements. NCHRP, Rept. 162, 1975.
3. P. C. Box and J. C. Oppenlander. Manual of Traffic Engineering Studies. Institute of Transportation Engineers, 1976, pp. 203-207.
4. R. M. Michaels. Two Simple Techniques for Determining the Significance of Accident-Reducing Measures. Traffic Engineering, Sept. 1966, pp. 45-48.

Publication of this paper sponsored by Committee on Traffic Records.

Michigan Dimensional Accident Surveillance (MIDAS) Model: Progress Report

Thomas L. Maleck, Michigan Department of State Highways and Transportation

The Michigan Dimensional Accident Surveilance Model is being developed by the Michigan Department of State Highways and Transportation. The model aims to objectively analyze the entire roadway system (not just locations with the worst accident histories), to select candidate locations for upgrading that are the most sensitive to correction, and to choose sets of the most likely cost-effective corrective measures. This paper introduces the procedures; reports on progress, accomplishments, and shortcomings to date; and stimulates related interest and development elsewhere. The model may be visualized as grouping all roadway segments with identical predetermined physical and accident characteristics into one cell of a multicell array. Subsequent statistical analysis, cost estimating, and accident predictions assess probable impacts on transforming all sites from one cell type to another. Data sources are several master tapes of accident reports, road features inventory files, and a traffic volume file. The identification of segments having a statistically significant number of accidents and the determination of logical countermeasures work well. The prediction of expected accidents for each corrective action at present lacks precision and requires additional work.

The Michigan Department of State Highways and Transportation has maintained computerized accident report data since 1963. Candidate locations for possible spot safety improvements were selected, in rank order, by total accidents and accident rates for 0.3-km (0.2-mile) roadway segments. Threshold values were used to control the size of the listing. The same locations tend to appear year after year. Feasible corrective treatments are eventually exhausted. Yet engineering attention is still given, although lower ranked candidate sites may not be investigated due to limitations of time, personnel, and funding.

MODEL DEVELOPMENT

A desire to identify sites with correctable accident patterns (independent of the number of total accidents) initiated the development of an accident analysis system—the Michigan Dimensional Accident Surveillance (MIDAS) model. The guiding objectives for model development are to

1. Greatly expand knowledge by including as much pertinent information as possible in the analysis;
2. Analyze objectively the entire roadway system, not just locations with poor accident histories;
3. Optimize injury avoidance;
4. Select candidate locations that are the most sensitive to correction and select sets of corrective measures that are likely to be the most cost effective; and
5. Provide a managerial tool to test policy.

The model consists of three stages: (a) locating all sites with statistically significant injury accident patterns, (b) investigating all feasible countermeasures, and (c) optimizing expenditures based on cost effectiveness. Due to spatial limitations, this paper will primarily address the progress in developing stage 1.

The principal concept of stage 1 is to aggregate roadway segments with similar physical and environmental characteristics into one cell of a multicell array, with the array containing all conditions in the universe. The dimensions and principal variables are

1. Geometry—number of lanes, horizontal alignment, vertical alignment;
2. Environment—roadside development, day/night, wet/dry, intersection/midblock, operational controls;
3. Cross section—lane width, shoulder width, curb type; and
4. Accident—accident characteristics.

From these variables, it is mathematically possible to create 514 080 data sets. Most of the conditions do not exist; approximately 20 000 cells contain real-world data.

The model uses several data files. Accident data for each year are obtained from accident master tapes. Files of accident data are created for each of the department's nine districts for the years 1971 through 1975 plus the cumulative five-year period. Geometric and environmental files are created for each of the nine districts. The state highway and transportation department's photolog provided most of the data, thus limiting the precision of some variables. Another file set contains traffic volumes with hourly and 24-hour summaries. The vehicular counts are available for approximately every 4 km (2½ miles) in the system. There are three file sets containing volume conversion factors by year, month, and day of the week. Remaining files contain modified highway capacity factors derived from the TRB Highway Capacity Manual. A file set with English description of the routes, crossroads, local governmental agencies, and counties is available.

STAGE 1 PROCEDURES

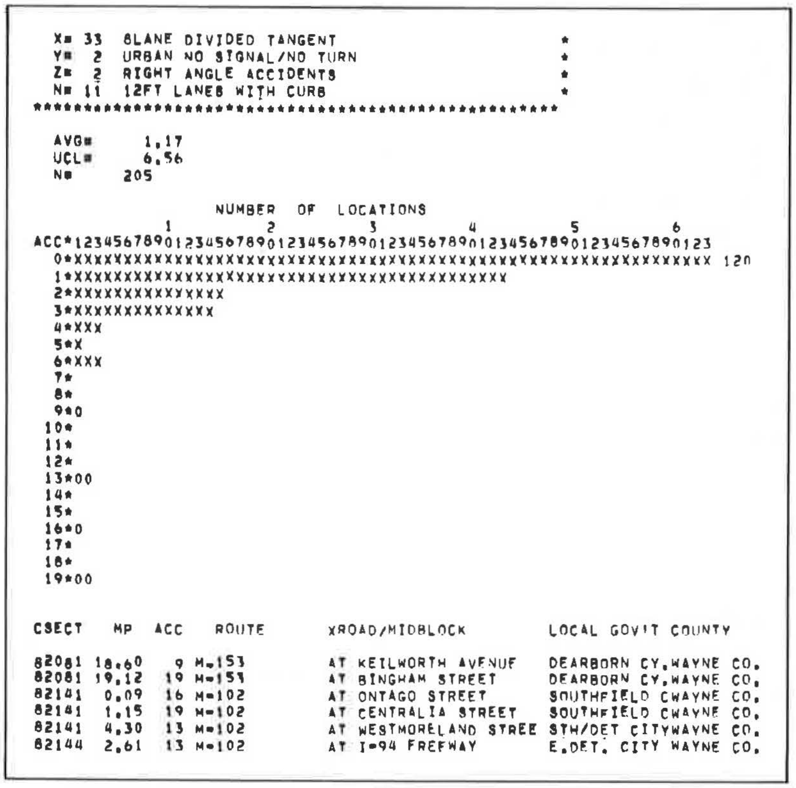
The procedures in stage 1 for identifying statistically significant accident patterns consist of several computer programs. The principal computer program simultaneously reads eight file sets. The model steps down the trunkline system in 0.3-km (0.2-mile) segments. Reading precoded characteristics at segment midpoints, it determines such factors as basic laneage, lane width, shoulder width, and horizontal and vertical alignment. It then ascertains the number and type of injury and fatal accidents that occurred in a given segment. For each discovered accident, the model also calculates segment roadway capacity and checks upstream and downstream for the nearest recorded traffic volumes. It factors both volumes to estimate hourly volume at the time of the accident. The volume-to-capacity ratio is then calculated for the recorded hour of the accident. After this process is completed for midblock segments, it is repeated for intersections. Only injury and fatal accidents (without discriminating) are analyzed. This alleviates a difficulty of inconsistent reporting of property damage accidents between rural and urban areas and promotes a desire to emphasize injury-avoidance improvement projects.

Cells are created by assigning X, Y, Z, and N subscripts (geometry, environment, accident, and cross section) to each segment and subsequently sorting the data by ascending order of the subscripts. The data in each cell are tested for a goodness-of-fit to a Poisson distribution; a mean, variance, and upper limit are calculated. Figures 1 and 2 are cell outputs from the X, Y, Z, and N array. There is also a procedure for the interactive aggregating of variables allowing one to analyze several million combinations of variables and aggregations of variables with an output similar to Figures 1 and 2.

Figure 1 illustrates a cell containing all segments that have these characteristics: eight lanes divided, tangent alignment, urban development, nonsignalized intersections, no auxiliary turn lanes, right-angle injury accidents, 39-m (12-ft) lanes with curb and gutter. There are 205 intersections with similar characteristics with a mean of 1.17 right-angle injury accidents in 5 years. Of the total sample, 120 had no right-angle accidents; two had 19 right-angle accidents each (significant at the 99 percent level). At the bottom of the histogram, English descriptions of sites with significantly large frequencies—called outliers—are provided. Outliers are easily identified and have a different perspective when viewed with like locations as opposed to a singular high accident listing.

Figure 2 is similar to Figure 1 and is an example of a cell with a much larger sample size—1258 sites—and represents all injury accidents per site in lieu of a spe-

Figure 1. Illustration of a cell containing all segments that have certain characteristics such as eight lanes divided and tangent alignment.



```
   X= 33  8LANE DIVIDED TANGENT                           *
   Y=  2  URBAN NO SIGNAL/NO TURN                         *
   Z=  2  RIGHT ANGLE ACCIDENTS                           *
   N= 11  12FT LANES WITH CURB                            *
*****************************************************************

   AVG=      1.17
   UCL=      6.56
   N=       205

                   NUMBER  OF  LOCATIONS
             1         2         3         4         5         6
ACC*123456789012345678901234567890123456789012345678901234567890123
   0*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 120
   1*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   2*XXXXXXXXXXXXXXX
   3*XXXXXXXXXXXXXX
   4*XXX
   5*X
   6*XXX
   7*
   8*
   9*0
  10*
  11*
  12*
  13*00
  14*
  15*
  16*0
  17*
  18*
  19*00

CSECT   MP   ACC   ROUTE         XROAD/MIDBLOCK        LOCAL GOV'T COUNTY

82081  18.60   9 M-153          AT KEILWORTH AVENUF   DEARBORN CY.WAYNE CO.
82081  19.12  19 M-153          AT BINGHAM STREET     DEARBORN CY.WAYNE CO.
82141   0.09  16 M-102          AT ONTAGO STREET      SOUTHFIELD CWAYNE CO.
82141   1.15  19 M-102          AT CENTRALIA STREET   SOUTHFIELD CWAYNE CO.
82141   4.30  13 M-102          AT WESTMORELAND STREE STH/DET CITYWAYNE CO.
82144   2.61  13 M-102          AT I-94 FREEWAY       E.DET. CITY WAYNE CO.
```

Figure 2. Illustration of a cell with a large sample size (1258 sites), representing all injury accidents per site in lieu of a specific accident pattern.

```
 X=  2  2LANE/2WAY TANGENT WITH PASSING ZONE          *
 Y= 18  RURAL NO SIGNAL/NO TURN                       *
 Z=  1  TOTAL ACCIDENTS                               *
 N= 14  12FT LANES WITH 8-10FT SHOULDERS              *
*****************************************************

 AVG=      0.97
 UCL=     13.77
 N=     1258

                   NUMBER  OF  LOCATIONS
            1         2         3         4         5         6
ACC*123456789012345678901234567890123456789012345678901234567890123
  0*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 749
  1*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 265
  2*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX  97
  3*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  4*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  5*XXXXXXXXXXXXXXXXXXXXXXXX
  6*XXXXXXXXX
  7*XXXXX
  8*XXXXXX
  9*X
 10*X
 11*XX
 12*X
 13*XX
 14*
 15*
 16*0
 17*0
 18*0
 19*0
 20*
 21*
 22*
 23*
 24*0
 25*
 26*
 27*
 28*0


CSECT   MP  ACC   ROUTE         XROAD/MIDBLOCK         LOCAL GOV'T COUNTY

11101  2.55  28 US-12          AT 3RD STREET           NILES TWP   BERRIEN C
19031  1.99  17 US-27          AT STOLL RD             DEWITT TWP  CLINTON
61151  3.45  18 US31BR,I96BS AT SEMINOLE RD            NORTON SHOREMUSKEGON
61151  4.14  19 US31BR,I96BS AT GREEN ST               MUSKEGON HEIMUSKEGON
61151  4.74  24 US31BR,I96BS AT GETTY RD               NORTON SHOREMUSKEGON
76021  3.70  16 I-69           AT SHAFTSBURG ROAD      WOODHULL TWPSHIAWASSE
```

Figure 3. Graphic output of data for 1 year (1975) of accidents and the noted cell conditions.

```
      ***************************
      *2 LANE  2 WAY  RURAL     *
      *10 F LANE INTERSECTIONS *
      *4-8 FT SHLDS  55MPH      *
      ***************************
      TOTAL SAMPLE SIZE =      266
         MEAN V/C RATIO =    0.170
                                                    NUMBER OF ACCIDENTS
                1         2         3         4         5         6         7         8         9         0
V/C     *1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
0.050 *XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                          60
0.100 *XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                                        46
0.150 *XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                                            42
0.200 *XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                                                38
0.250 *XXXXXXXXXXXXXXXXXXXXXXX                                                                               23
0.300 *XXXXXXXXXXXXXXXXXXXXX                                                                                 21
0.350 *XXXXXXXXXX                                                                                            10
0.400 *XXXXXX                                                                                                 6
0.450 *X                                                                                                      1
0.500 *XXXX                                                                                                   4
0.550 *X                                                                                                      1
0.600 *XXXX                                                                                                   4
0.650 *XXX                                                                                                    3
0.700 *                                                                                                       0
0.750 *X                                                                                                      1
0.800 *                                                                                                       0
0.850 *X                                                                                                      1
0.900 *XX                                                                                                     2
0.950 *X                                                                                                      1
1.000 *                                                                                                       0
1.050 *                                                                                                       0
1.100 *X                                                                                                      1
1.150 *                                                                                                       0
1.200 *                                                                                                       0
```

cific accident pattern. The process for identifying outliers relies on statistical significance and dispersion from the cell mean (measured by the number of standard deviations) and is relatively insensitive to the accident pattern, sample size, or magnitude of accidents frequency. Earlier a procedure was described for estimating the volume-to-capacity ratio for the recorded hour of the accident. Figure 3 is a graphical output of the data for 1 year (1975) of accidents and the noted cell conditions.

OTHER STAGES

Stage 2 involves the analysis of each outlier with a significantly high concentration of accidents. Logical countermeasures are identified by increments—e.g., widen lane from 33.3 m to 36.3 m (10-11 ft), add left-turn lane, right-turn lane, and signalization—with each incremental change being cost estimated. This is accomplished by having the outlier float through a decision tree. The resistance to each change (moving from one mode to another) is measured by an estimated cost. The expected change in accidents is estimated for each countermeasure, including the do-nothing alternative. The cost of each countermeasure is divided by the anticipated reduction in accidents, producing a cost-effectiveness index for each proposal. The status of stage 2 is a preliminary working program for identifying and estimating the cost of countermeasures. Present accident predictive procedures are not satisfactory, and more comprehensive accident predictive algorithms are being developed.

Stage 3 is the model optimization process. The objective is to maximize expected returns within budget and management policy constraints. Theoretical procedures have been explored but will not be implemented until the completion of stage 2. Action is under way to accelerate the completion of the model, its validation, and expansion to access sources of data heretofore unobtainable.

ACKNOWLEDGMENTS

Several engineers and technicians, who labored in developing and editing the base data and subsequent software, deserve much credit. Special consideration is due Donald E. Orne, Traffic and Safety Division, for his substantial contribution in formulating the concepts and processes of the model.

Publication of this paper sponsored by Committee on Traffic Records.

Accident Characteristics Before, During, and After Safety Upgrading Projects on Ohio's Rural Interstate System

Zoltan A. Nemeth, Department of Civil Engineering, Ohio State University
Donald J. Migletz,* Ohio Department of Transportation

In 1973, minor safety upgrading projects were conducted at 21 locations on the rural Interstate system of Ohio, involving 618 km (384 miles) of freeways. In 1972, the accident rate per million vehicle kilometers (MVKM) on these 618 km was 112.9 accidents/161 MVKM (112.9/100 million vehicle miles). In 1974, the accident rate dropped to 77.9 accidents/161 MVKM. To account for the possible effect of the introduction of the reduced speed limit in 1974, accident rates were also compared on 246 km (153 miles) of the rural Interstate system not subjected to safety improvement. The difference in proportional reduction in accident rates is statistically significant and favors the 21 study sites. The accident rates increased to 120.8 accidents/161 MVKM during the 1973 safety upgrading construction program. However, only 151 accidents were positively identified from traffic crash reports and construction diaries as construction related. These 151 accidents were studied in detail. Observed patterns included: (a) rear-end (61) and single vehicle, fixed-object (56) accidents were the most frequent; (b) 34 accidents occurred in the relatively short taper area; (c) the proportion of the lane taper accidents at night and at dawn or dusk was high; (d) the proportion of construction object accidents at night was high; (e) the proportion of tractor-trailer and bus accidents at night was high; (f) excess speed was listed in 88 cases as a contributing factor, while road defects or construction or traffic control were listed only in 15 cases. Some suggestions are being made regarding traffic control at work zones.

INTRODUCTION

The implementation of the Interstate highway system began in 1956 with the passage of the historic Highway Revenue Act and Federal-Aid Highway Act. The Interstate system is now about 90 percent completed. However, once a facility is constructed, it requires continuing attention to operation and maintenance.

Naturally, all highways will deteriorate in time at a rate determined by the traffic and environmental conditions. Resurfacing and other corrective measures are required to maintain the original design standards and the corresponding efficiency and level of safety.

Since the original design standards for freeways were developed, research, as well as experience gained from operating freeways, has taught us much about the relationship between design standards and performance. To eliminate safety hazards unwittingly built into our freeways, a 90 percent federally-supported Interstate Highway Safety Upgrading Program was begun.

For administrative purposes, safety improvement projects on the Interstate highways are classified as either major or minor upgrading. Major improvements are cost-intensive projects that are usually expected to reduce accidents. Minor improvements are low-cost projects and are usually expected to reduce the severity of accidents, mostly through reduction of roadside hazards.

Ohio's Interstate Highway Safety Upgrading Program was implemented in the early 1970s. It was rather puzzling to find, therefore, in the course of a previous study, that accident rates in Ohio actually exceeded projected trends during the first few years of the 1970s.

It is clear that safety upgrading projects differ from most new construction projects in that traffic must flow uninterrupted while work is in progress. This, of course, presents potential hazards to construction workers and through traffic alike. This realization led to the theory that safety upgrading projects may be responsible, at

---

Mr. Migletz was a graduate student at Ohio State University at the time this study was conducted.