NEAR-MISS DETERMINATION THROUGH USE OF A SCALE OF DANGER

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Near-miss traffic events have been considered but not adopted as a traffic safety tool because of the high degree of subjectivity involved with their identification. A scale of danger may be applied to a traffic event to facilitate objective measurement and subsequent detection of near-miss situations. The unit proposed here for this danger scale is the time measured until collision between two vehicles involved in the unsafe event. This measure, computed from films taken with the Traffic Sensing and Surveillance System of the Federal Highway Administration at an urban intersection, is an adequate unit to rate the danger of almost any traffic event. It may be used to standardize human observer judgment of dangerous maneuvers and, therefore, make near-miss monitoring a viable alternative to traffic safety determination.

•NEAR-MISS traffic events have been considered for use as predictors of accident rate characteristics at roadway locations. The near miss, loosely defined, is a traffic event that produces more than an ordinary amount of danger to the drivers and passengers involved. Near misses would appear to be closely related to the accident pattern witnessed at a location and, therefore, could become an attractive alternative measure to accident-based safety determination.

Although the use of near misses seems appealing for safety monitoring, near misses have never been seriously considered as accident predictors because their detection and classification involves a great deal of judgment on the part of the observer. An event that looks dangerous to an observer who is a conservative or inexperienced driver may appear commonplace to an observer who drives very aggressively. Consequently, counts of near-miss events could vary substantially because of the differences in the personalities and driving experiences of the observers. Because judgment of near misses requires a subjective judgment of danger, near-miss measurement has been rendered virtually useless as a traffic engineering tool.

Because almost every traffic event has a certain level of danger associated with it, there is a need for establishing some threshold level for use in distinguishing near misses from less dangerous events. The fixing of this danger level requires a scale of danger that is physically measurable for a traffic event. If the danger level for each event can be rated on a common scale, the events can be ranked in order of danger.

The objective of this research was to define in physical terms a measurement of the danger involved in a two-vehicle interaction. This measurement may be used to establish a limit that would distinguish a near miss from other dangerous traffic events. The study was intended to provide a measurable frame of reference for degree of danger that could be used for standardizing human judgment of near-accident traffic events.

The dangerous events considered in this study were confined to two-vehicle interactions at an urban intersection during off-peak volume periods. The concept developed, however, may be easily extended to single-vehicle-fixed-object interactions and to other highway environments.

Sponsored by Committee on Effectiveness of Operational Measures.

TRAFFIC SENSING AND SURVEILLANCE SYSTEM

The measurement of motion and positional parameters involved in a two-vehicle interaction must be done by analyzing motion picture film. Film provides an accurate time base and instantaneous position points from which vehicle velocities and accelerations may be calculated.

The Traffic Sensing and Surveillance System (TSSS), developed by the Federal Highway Administration (FHWA), was used to record the film required for this study. The system has a unique instant-replay capability that makes it ideal for filming selected traffic events that occur with no discernible regularity.

The TSS System used two television cameras positioned on opposite corners of the intersection of 14th and F Streets in Washington, D. C. The cameras monitored the intersection action and recorded it continuously onto a magnetic video disc. The disc had a 20-sec storage capacity; when the 20 sec was reached, the recording arm recycled and recorded the next 20 sec onto the disc and erased the previous recording as it proceeded. Upon command, however, the video disc could be played back and the 20 sec of action could be transferred onto 16-mm motion picture film for a permanent recording of the selected event. The system gave the observer the capability to record on film the intersection action that occurred in the 20 sec prior to the activation instant.

The 16-mm film presented a sufficiently clear and precise picture for vehicle identification and tracking. The field of vision included the intersection itself and approximately 200 ft of each intersection leg, which permitted the observation and recording of near misses occurring both at the junction and in the approaches.

FILM SITE

The location chosen by the FHWA for installation of their TSS System was the intersection of 14th and F Streets located in the central business district of Washington, D. C. Its selection was based on site requirements for the TSSS hardware, but it proved to be an excellent site for the research reported here. The intersection is typical of intersections of surface streets in any large metropolitan area. It is signalized and handles high volumes of both pedestrian and vehicular traffic. Figure 1 shows the intersection's geometric configuration; about 35 to 40 accidents per year are reported at this location.

FILMING PROCEDURE

Sequences of dangerous traffic events were selected for filming by observing real-time television monitors in the TSSS control room during the data collection days of April 8 and 9, 1970. Each television camera relayed a picture of the intersection back to the control room for display on a monitor. Each camera view covered approximately one-half of the intersection with a certain amount of overlap at the center. The two television monitors were arranged to simulate an overall aerial view of the entire location. It was a simple matter to track a vehicle from one camera view to another through this arrangement. After a short adjustment period, the observer had a very good orientation for viewing the entire intersection simultaneously, as if suspended high above the center of it.

Additional information on traffic conditions was provided through an audio connection with the intersection. A ground-level microphone transmitted sounds from the street to the control room. This provided the observer an audio cue to the real-time events occurring at the intersection; the sounds of horns blowing and tires squealing were clearly distinguishable from the regular traffic noise. These two specific noises seemed to be indicative of a dangerous situation and were very useful taking films of dangerous traffic events.

The general plan of film collection was to observe the entire intersection through the monitors to detect near misses. Because only two intersection approaches were in motion at once, it was fairly simple to monitor all vehicular action simultaneously. When two vehicles appeared to be in a dangerous situation, the magnetic disc was operated in the playback mode. The 20 sec of action stored there were projected on a third monitor for filming by the motion picture cameras. The criterion used for activation was completely subjective and followed the general definition that a near miss is an event that produces more than an average amount of danger.

The time of observation for near misses was restricted to periods from 9:30 a.m. to 1:00 p.m. and 2:00 p.m. to 4:00 p.m. on both days of data collection because of TSSS equipment considerations. The afternoon period of the second day was not utilized because the amount of film provided by the FHWA had been exhausted, and it was felt that a sufficient number of sequences had been recorded. A total of 90, 20-sec segments was recorded for study.

DATA REDUCTION

The filmed events were reduced to tabulations of motion parameters to analyze the sequences quantitatively. The data reduction technique employed a Benson Lehner Oscar Model F film reading device to reduce the points of interest in each frame to coordinate points punched onto a computer card. These coordinates were transformed from film-reader Cartesian coordinate points to ground-level coordinates by using a series of regression equations. The resulting points were used, with the frame speed as a time base, for motion calculations for the two vehicles involved. These calculations were performed by a computer program modified from the original analysis program for the TSS System written at Cornell Aeronautical Laboratories.

The final result of the data reduction technique was the computer printout of the motion and spacing parameters for each vehicle at each frame point in the analyzed sequence. These parameters were presented in both a tabular listing and a graphic representation to ensure that an accurate and recognizable representation of the interaction dynamics was given. Velocity, acceleration, coordinate positions, spacing, and time to collision were presented for analysis.

NEAR-MISS MEASUREMENT

The initial approach to the problem of near-miss definition centered on the derivation of separate definitions for each type of encounter. The near misses were grouped by type categories such as the type of accident that would have occurred if a corrective maneuver had not been made and then different threshold levels of velocities and spacings were assigned as the near-miss definition. It was anticipated that this threshold level would be based on calculated theoretical values.

For example, in the case of a vehicle quickly changing lanes into the path of a second vehicle, a calculation to determine a near miss could be based on the stopping distances of the two cars involved. If, for some reason, the first car had to make a panic stop sometime after pulling into the path of the second car, the distance required to bring the first vehicle to halt could be calculated by using an assumed friction factor between the roadway and the tires. The second car would also be required to stop suddenly which would be a function of that vehicle's speed and coefficient of friction plus the distance traveled during the reaction time of the driver. Given the spacing of the vehicles, it could be calculated whether a rear-end collision actually would have occurred if the first car had suddenly stopped.

These situations where accidents would have taken place, given certain conditions, would seem to describe near-miss situations for the specific given condition. Unfortunately, there are too many conditions that control the actions and reactions of drivers to make all required classifications possible. If, for instance, in the preceding example the trailing car had swerved out of the collision path, the near-miss criterion measure would not hold. The numerous possibilities of accident instigation and avoidance that could occur in a two-vehicle interaction at an urban intersection made this type of approach impossible. Each near miss seemed to have its own set of conditions, which made the calculations of each event unique.

TIME TO COLLISION

Effort was directed toward development of an objective measure that would apply to all types of near-miss situations. This resulted in the development of the parameter recommended here, the time-measured-to-collision (TMTC) measure of danger. It was observed on the films that the traffic flow at the intersection seemed to be smooth until a perturbation was introduced. When a driver would make an error and cause a dangerous condition, the affected drivers would compensate to avoid collision, and the flow would return to a stable condition. Thus, the danger seemed to increase and then subside.

The TMTC measure was thought to reflect this subjective feel for the near-miss phenomenon in which danger peaks and then subsides. Very simply, the measure is the time required for two vehicles to collide if they continue at their present speeds and on the same path. It is a measure continuous with time; that is, the calculation may be performed at any instant within the sequence time frame.

Automobiles are frequently driven on paths of collision with other vehicles, pedestrians, or fixed objects. The reason collisions do not often occur is that drivers are constantly making the necessary speed and heading changes to avoid crashing. Therefore, almost all driving, except in the middle of a perfectly flat, deserted plane, involves a certain element of danger. Traffic events where corrections to evade collisions must be made in a very short time are what we intuitively call a near miss. It follows that the real degree of danger to drivers may be measured by calculating the time available to them to make the necessary correction to evade an accident. A near miss is nothing more than a traffic event with a low TMTC value associated with it.

A curve of the TMTC measure during a near-miss event plotted against time should be concaved upward, reflecting the increasing and then subsiding danger as a near miss passes. The theoretical shape of a simple near-miss curve of TMTC values versus time is shown in Figure 2.

A way of visualizing a real-life event that results in this curve is to consider the special case of a car-following situation with unequal speeds. If the lead vehicle is traveling at a slower pace than the following vehicle, there is a definite time to collision. As the vehicles draw nearer, the TMTC value will drop. The decrease will be linear as long as constant speeds of both vehicles are maintained. When the driver of the following vehicle senses the impending collision, he would slow his car and thus decrease the TMTC value. The following driver would continue to slow until the speed of his vehicle coincided with that of the lead car and a collision would not occur. If a collision cannot occur, the TMTC value is infinity.

The calculation of the TMTC value was added to the computer program, which produced the velocities and spacing determinations for each near-miss sequence. The method of the calculation was adopted from a navigation computation by which ships determine how close they will pass. One vehicle was considered stationary, and the second was considered to move with respect to the first. A collision was imminent when the relative velocity vector extending out from the moving vehicle passed through the stationary vehicle.

THEORETICAL BOUNDS OF TMTC

The maximum TMTC value of any two vehicles is infinity. Because drivers do not ordinarily drive on a collision course with other vehicles, it was expected that no-collision values were to be found in the output of the near-miss analysis program. The normal and safest value of time to collision for a given traffic event would be infinity.

The minimum value of a TMTC measure for a near miss would be the driver's perception plus reaction time. This time is the time required for the driver to perceive the imminent danger of collision and to decide a course of action and implement it plus the time needed for the vehicle to respond to the driver's command in order to avoid collision. If the TMTC value drops below this level, a crash will occur because there is not enough time for avoidance.

A numerical value of the minimum TMTC measure would be approximately ½ sec. This approximate value is estimated by using braking reaction time given elsewhere (1). There is difficulty in assigning a rigid value to the absolute minimum because all of the drivers involved in a near miss have an opportunity to attempt to avoid collision. The

Table 1. Minimum TMTC values.

Rank	Near-Miss Code Number	TMTC Minimum (sec)	Type
1	3-17	0.20	Rear-end
2	1-1	0.30	Lane-change
3	2-14	0.35	Right-of-way
4	2-6	0.40	Lane-change
5	1-3	0.45	Lane-change
6	1-4	0.55	Lane-change
7	1-2	0.60	Lane-change
8	1-23	0.65	Lane-change
9	2-5	0.70	Cutoff
10	1-14	0.80	Rear-end
11	3-18	0.80	Cutoff
12	3-19	0.80	Rear-end
13	2-1	0.90	Cutoff
14	2-2	0.90	Rear-end
15	3-13	0.95	Lane-change
16	4-1	1.15	Cutoff
17	4-7	1.15	Rear-end
18	4-5	1.20	Cutoff
19	1-13	1.25	Cutoff
20	1-19	1.30	Lane-change
21	3-10	1.35	Cutoff
22	4-10	1.40	Lane-change
23	4-13	1.45	Lane-change
24	2-11	1.50	Right-of-way
25	3-14	1.75	Cutoff
26	1-21	1.80	Cutoff
27	4-9	2.00	Lane-change
28	2-16	2.00	Rear-end
29	1-10	2.15	Rear-end
30	1-7	2.25	Lane-change
31	3-20	2.25	Broadside
32	2-4	2.35	Lane-change
33	4-3	2.40	Lane-change
34	4-8	2.55	Right-of-way
35	1-11	2.75	Rear-end
36	3-15	2.80	Lane-change
37	2-7	3.40	Lane-change
38	4-15	3.95	Cutoff

Figure 1. Study intersection.

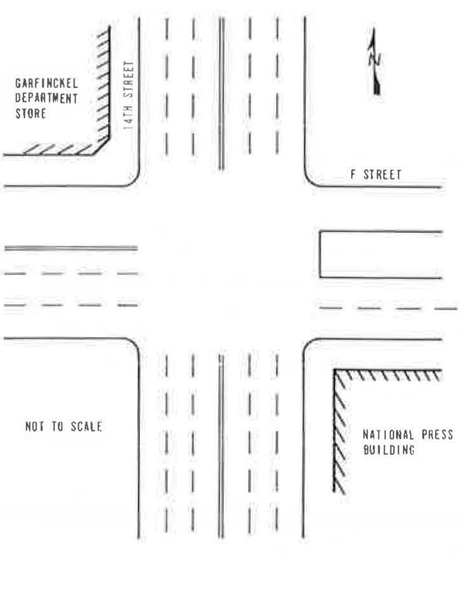
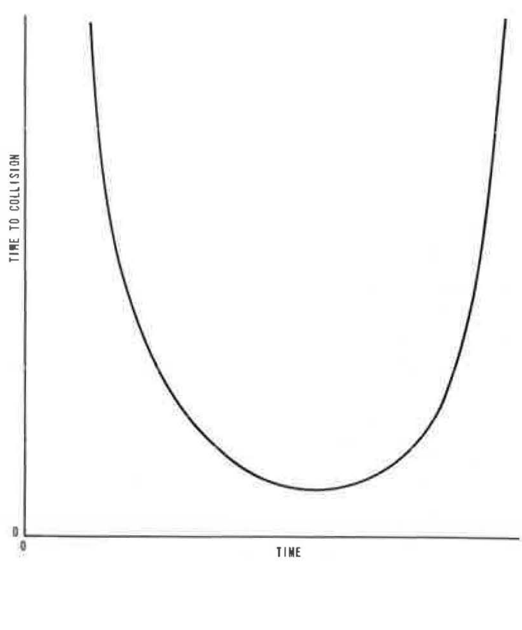


Figure 2. Theoretical TMTC curve.



vehicular response times would be a function of the vehicle itself and the maneuver that the driver directs it to perform. How much avoidance is necessary for one vehicle is a function of the avoidance action taken by the other driver. The ½-sec value represents the time required for one driver to apply his brakes; it does not include the time required to stop. Vehicular response times might be considered effectively zero because each driver can correct simultaneously.

RESULTS

The final results of the data collection and reduction were tabular and graphic computer printouts of each near-miss sequence. Of the 90 sequences that were filmed, 54 were analyzed. The reason for the large discrepancy in the number filmed and the number analyzed was that many sequences were too poor in quality to permit clear visibility on the film analyzer.

Of the 54 sequences analyzed 43 produced usable data. The 11 sequences that were dropped from consideration after they had been analyzed were deleted because the computer analysis method appeared to break down for their situations. The TMTC output was either too erratic or the minimum values were too low to be believable.

The erratic sequences were probably caused by invalid vehicle width assumptions. The left front fender of each vehicle was the only point that was analyzed and transformed for use in motion parameter calculations; but all other fender points were required for the TMTC calculation. The computer program solved for them by using an assumed vehicle length and width and a vehicle direction indicated by the slope of the velocity vector.

When two cars are in a side-by-side position, as they often are in a lane-change or swerving maneuver, the assumptions of width are critical. If the assumed widths are greater than the actual widths, the side-by-side vehicles would be unreasonably close. A small change in heading from parallel paths would cause them to have extremely low TMTC values. When the headings are parallel or divergent, the time to collision is infinite. Each of the four sequences that was disregarded because of the erratic behavior of the TMTC curve involved a parallel movement, a fact that served to validate the previous contention.

If the length of the vehicle is assumed to be larger than the true length, the entire TMTC curve would be moved toward zero. Unlike the width effect, the length effect would cause smooth curves that touch the zero TMTC value. A zero-time-to-collision value implies that the cars have collided, but the films showed this to be untrue. An increase in length increased the real distance between cars in the car-following situation so that as the rear car approached, the TMTC value reduced smoothly but down to an artificially low level. Of the seven sequences discarded for this reason, five involved car-following situtations. The remaining two sequences were concerned with very closely spaced vehicles where either length or width assumptions could have artificially lowered the TMTC curve.

TIME-TO-COLLISION ANALYSIS

Most of the remaining 43 sequences behaved according to the foregoing theory. The curves generally were of the concave upward shape, which the theory suggested to be the near-miss pattern. Figure 3 shows a typical TMTC curve based on data from this research. For five of the remaining 43 near-miss sequences no points on the TMTC curves fell below 999 sec. This indicated that they were never on a collision course. This was not a startling result because there was no preconceived notion of the TMTC measure at the time of data collection. The events were selected as potential near misses only on the basis of definition.

An ordered list of minimum TMTC values is given in Table 1. Each TMTC curve was evaluated for the minimum value in the near-miss zone of the curve. Often, after the TMTC curve had returned to the maximum value, stray points of low TMTC values would appear. This was caused by the width assumption explained previously. These points were not considered in the evaluation of minimum TMTC points, which ensured that the value selected for presentation in Table 1 represented the near-miss phenomenon and not the parallel vehicle inconsistency effects.

The near-miss types given in Table 1 are intended to generally describe the maneuver that was involved in the traffic event. They are as follows:

1. Rear-end—where a following vehicle was forced to stop suddenly to avoid an accident;
2. Lane-change—where a slow-moving car, by changing lanes into the path of a vehicle, caused the faster vehicle to either slow or swerve to avoid an accident;
3. Cutoff—where a turning movement across the path of a second vehicle caused it to alter its motion;
4. Broadside—where a driver passed into the intersection after the caution light had been activated and blocked the path of cross street traffic; and
5. Right-of-way—where two drivers proceeded to the same point and refused to grant a clear path to the other.

The mean TMTC minimum of all sequences that had vehicles on collision paths was 1.46 sec. The mean value was influenced by the large values at the lower end of the scale because the median TMTC value was 1.25 sec. Both values appear to agree with the theoretical values quite closely.

SUGGESTED MINIMUM FOR NEAR-MISS DEFINITION

On the basis of the absolute minimum TMTC values and the empirical values obtained from the TMTC measurements in the filmed sequences, it would appear that 1 sec would be a good threshold limit to impose on the measurement for a near miss. It is recommended that traffic events that display a minimum TMTC value of less than, or equal to, 1 sec should be designated as near misses and that events with greater values should not be counted. If this criterion were applied to the present study, 15 of the 43 sequences analyzed would be classified as near misses.

This level would certainly make the defined near miss an event that would occur frequently enough to satisfy the data-collection requirements of an alternative safety monitoring method. Data were collected at the Washington site for only 9 hours; 90 filmed sequences were made. If the same ratio of 15 defined near misses to 43 analyzed events can be applied to all the data collected, it would seem that near misses occur with a frequency of approximately 3.5 per hour at that site. Because the location shows an approximate accident rate 4- per year, the ratio of near misses to accidents would suggest that a number of near misses equivalent to 1 year's accident history could be collected in 1 day's observation.

SPECIAL CASES

The empirical curves derived from the filmed sequences suggest that a near-miss event is not quite as simple as was theorized. One disagreement between theory and actual data comes about through the existence of double-minimum points within the same TMTC curve. This means that the TMTC value decreases to a minimum and then arises again as predicted. Instead of continuing to rise to infinity, the time to collision drops a second time to a minimum and then goes to infinity. An example of this double-minimum curve is shown in Figure 4.

This result may be explained by assuming that one vehicle makes a second move that places the two cars in danger of colliding. If the first driver places his vehicle in danger of being hit by a second and the second driver acts to avoid the crash, the TMTC curve will dip downward and then begin to rise again. It appears that in double-minimum TMTC circumstances, the first driver senses the action of the second driver and elects to force the issue a second time by again placing his car onto a collision path. The avoidance of the second collision results in the second fall of the TMTC curve.

Another surprising result that deviates from the near-miss theory is the existence of a horizontal TMTC curve at approximately the 2- to 3-sec level of time to collision. It implies that some drivers choose to drive so aggressively that they are on the point of collision for relatively long periods of time. A plot of one of the curves exhibiting this trait is shown in Figure 5. The phenomenon was particularly evident in right-of-way types of sequences where each driver was reluctant to allow the other to proceed in his

Figure 3. Typical empirical TMTC curve.

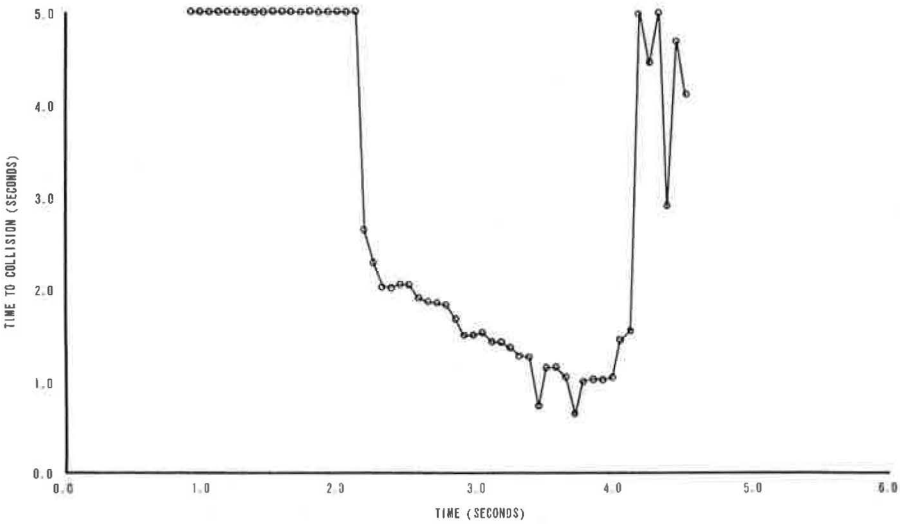


Figure 4. Double-minimum TMTC curve.

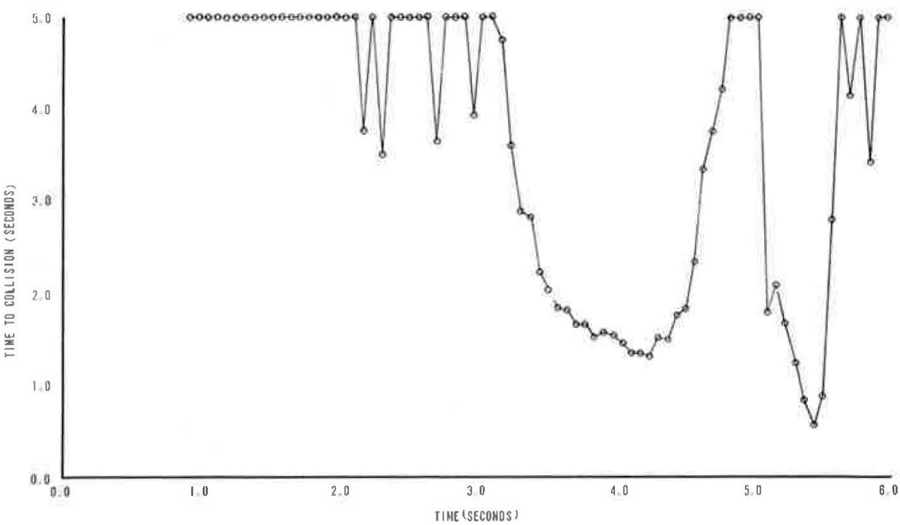
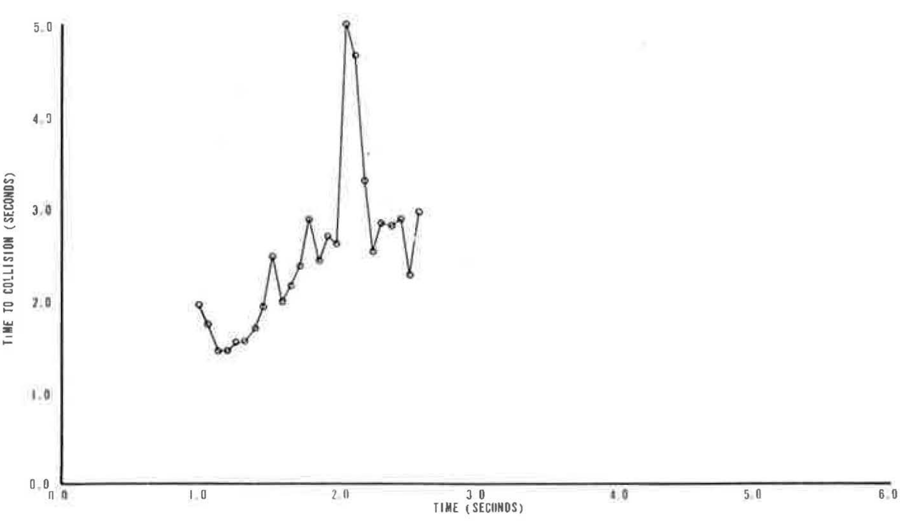


Figure 5. Horizontal TMTC curve.



desired direction. In congested urban locations this kind of excessively aggressive driving is not uncommon and could be expected to produce near misses.

HUMAN OBSERVER TRAINING

It is obvious that the elaborate equipment and data reduction methods employed in this study cannot be duplicated at every site where near-miss counts are desired. The near-miss method could never be justified if photographic data were a requirement for data collection. The following section is intended to present an outline of further long-range research of near misses that must be undertaken if the concept is to progress past the definition phase.

It would be desirable to investigate the possibility of teaching human observers to recognize near-miss situations as defined by the TMTC criterion. Although the inaccuracy of subjective judgment is the very thing that this paper intended to remedy, it is anticipated that with proper training the human judgment factor could be reduced to a tolerable level for data collection uniformity. Drivers are constantly required to judge the time to collision for their own vehicles while maneuvering in traffic, and they seem to do it relatively accurately. Discussions with Richard A. Olsen, a psychologist at the Pennsylvania Transportation and Traffic Safety Center, have indicated that observers could be trained to recognize a level of time to collision with the accuracy of recognition dependent principally on the intensity of their training.

One experimental approach to accomplish this goal would be to investigate several locations using observers and films simultaneously. A threshold level of 1 sec would be imposed on the TMTC curve to define near misses, and the observers would be instructed to record those incidents falling below that level. Continuous filming of the intersection would be performed during the observation period so that a visual record of all events could be made. The films should be of sufficient quality that frame-by-frame analysis could be carried out on those events where the TMTC value was thought to be near the threshold level.

The reduced films could be used as a checking, as well as a teaching, device for the human ground-level observers. Measurements of how many near misses (as defined by film analysis) the observers failed to detect as well as how many events recorded by them actually could not be classed as near misses could be made. The results could be presented to the observers in order that they might learn from their mistakes. Teaching methods could be established that would optimize the training procedure in order to produce qualified near-miss observers and observation techniques.

The outcome of this phase of near-miss implemention would be a measure of the accuracy and uniformity of human-observer near-miss detection. If observers cannot be trained to recognize the event specified here based on a TMTC criterion, then at this point very little more can be done in a safety measure direction. In this case, the only useful result of this phase of the implementation program might be in the extensive collection of filmed near-miss sequences. They could be used in a microscopic analysis of drivers' accident avoidance processes.

ACCIDENT CORRELATION

If the results of the observer training proved to be satisfactory, the next step toward implementation would be the correlation of near-miss statistics with accident statistics. It is necessary for this correlation to exist or the count of near misses would indicate nothing about the accident trends of a location.

This could be accomplished by using the trained human observers to investigate locations using the near-miss measure. The results of many observations would be compared to the accident histories of the sites studied, and correlation coefficients would be computed.

High relationships between accidents and near misses must exist for each type of accident. Possible near-miss classifications that might be used would be the type of accident that would have occurred if avoidance attempts had been unsuccessful. High correlations within types would suggest that a multiplier could be adopted to transfer from near miss to accident rates for each accident type.

The problems and expense that accompany this step would be greatly reduced by using observers instead of cameras. The only data required would be those that were collected by experienced observers. Data reduction would be minimal. Therefore, many sites could be investigated, which is a highly desirable situation for accurate correlation results.

PROGRAM ESTABLISHMENT

The final step needed to turn the use of near misses into a traffic engineering tool is to establish a monitoring program that uses them. Once it has been proved that near misses are good indicators of accident histories, an adequate program to periodically survey the locations within an area could be instituted. Near-miss counts could be taken as routinely as traffic volume counts, and summaries of the findings could be prepared for use in high accident location detection and subsequent safety improvements determination.

A continuing training program for near-miss observers should be set up to ensure that the uniformity of judgment that is so essential in near-miss counting persists. This might be accomplished in several ways, depending on the results of the original observer training phase. One method might be to set up a permanent training facility, possibly incorporated into the driver testing facilities that are becoming fairly common across the country. Also, a program of near-miss training might be accomplished by showing filmed near misses to the trainees and grading them on their interpretations of the films.

CONCLUSIONS

The near-miss definition as embodied by the TMTC measure is a valid indicator of danger for two-vehicle interactions. The results of this research show that the TMTC value provides a basis for ranking traffic events according to the danger that they generate. The theoretical TMTC curve can be shown to fit most of the empirically derived curves drawn from the films taken of near misses. The curves differ only in minimum TMTC values, from which it can be concluded that the danger involved can be quantitatively represented by that value.

A human observer is a good judge of the TMTC curve even though he may not be aware of the theory involved. The films of near misses analyzed in this research were taken by pure observation of the urban intersection. The only notion of a near miss was defined by the original definition of a traffic event that produces more than an ordinary amount of danger to the drivers involved. This loose definition, when applied in observation, resulted in very few sequences where the TMTC value failed to fall below 5 sec. The observation technique was to look at television monitors rather than at the actual site so that perhaps even higher observation accuracy would be attained by live viewing. The prospects of training observers to recognize rigid definitions such as 1-sec TMTC minimum value appear to be promising.

The minimum TMTC point in the near-miss sequence occurs before the minimum distance between vehicles is reached in the sequence. From examination of the near-miss curves, it is generally true that these two points are not the same on the time axis. The explanation of this effect can be seen if a near-miss event is pictured in one's mind. If a collision does not occur, the frantic maneuvering to avoid it is performed at the same time that the vehicles are closing in on one another. When the avoidance is completed, the vehicles become more under control with respect to each other so that they might pass closer to one another with more confidence. This is the case in a braking or swerving type of near miss where very close distances between vehicles are common even though the danger may be slight. Vehicles are nearest to each other in a swerving situation when they are side by side. Unless the vehicles are traveling on intersecting paths, however, they have little chance of colliding. The TMTC value reflects the idea that distance between vehicles is not the most dangerous point in the interaction sequence.

Some drivers appear to maintain a constant TMTC value of 3 or 4 sec throughout a sequence. A few sequences when plotted showed that the TMTC curve was nearly horizontal throughout the analyzed time. It seems obvious that in this situation both of the participants were driving very aggressively and were refusing to grant the right-of-way to the other. This seemed to be true in the dangerous case of two cars trying to change into the same lane simultaneously. Neither would give way to the other so that an impending collision was present for a relatively long period of time.

Double-minimum points were noted in some near misses. This is probably the result of a less severe case of the same type of driving behavior that produced a horizontal TMTC curve. Perhaps in this double-minimum condition there is one aggressive driver forcing the situation on a second defensive driver. If the aggressor puts himself onto a collision path and the defensive driver grants the right-of-way, the TMTC curve moves upward. The second minimum point is caused by a second aggressive action that requires a second defensive maneuver, which restores high TMTC values.

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