INTRODUCTION

This paper is a continuation to the report prepared for the first workshop on traffic conflicts, held at Oslo, (Hakkert, Balasha, Livneh & Prashker, 1977). In the first report, the main features of the models developed were described and some of the early results were presented and discussed. At this time, the study has been completed. The main results will be presented and evaluated, and the complete method will be described.

For reasons of clarity, some parts of the first paper, mainly those concerned with definitions and with the theoretical basis, have been repeated in this paper.

THE THEORETICAL MODEL

In analogy to car-following models describing the motions of following vehicles in a traffic stream, an attempt was made to define the motions of two vehicles following each other through an intersection. Development of such a model could possibly lead to the detection of unusual events, assessment of the difficulty of various vehicle manoeuvres, and to the possible identification of those locations at an intersection where difficulties in manoeuvring are encountered.
The reactions and manoeuvres of vehicles on the approach to an intersection were studied. Manoeuvres were recorded continuously, so that a microscopic model of the traffic flow could be defined in the following way:

\[
\text{reaction} = \text{stimulus} \times \text{sensitivity}
\]

Most car-following models of this kind, as summarized by Herman (1966), deal with single lane traffic on an undisturbed straight section of highway, and define the reaction as a change in tangential velocity. The present model, however, extends the definition of reaction in order to handle interactions of pairs of vehicles on the approach to and through an intersection. For such cases, two dimensions of motion must be considered, and all terms of the model-reaction, stimulus and sensitivity, are defined accordingly. Two groups of variables are defined, one dealing with motion along the axis of travel, and the other dealing with angular motion, i.e. changes in direction of travel.

The resultant reaction is accordingly composed of a term of change in velocity - \(\Delta s\) and change in direction - \(\Delta \theta\), and taking into account the time element, the two parts of reaction become:

\[
\begin{align*}
\Delta s / \Delta t &= \text{change in tangential velocity} \\
\omega s &= \text{change in radial velocity}
\end{align*}
\]

where:

\[
\begin{align*}
\Delta s &= \text{tangential velocity} \\
\omega &= \text{radial velocity} \\
\Delta \theta &= \text{velocity change} \\
\Delta t &= \text{time interval}
\end{align*}
\]

The resultant reaction \(a_e\) is defined as:

\[
a_e = \sqrt{a_T^2 + a_R^2}
\]  \(\text{(1)}\)
In treating the motion of a pair of vehicles on the approach to an intersection, the stimulus and sensitivity have to be defined in terms of the various components of their motion for each manoeuvre and activity. These terms are determined for a pair of vehicles travelling straight through the intersection:

for stimulus: \( s_{n+1} - s_n \); \( \omega_{n+1} - \omega_n \)

for sensitivity: \( \lambda_{o1} (x_{n+1} - x_n)^{-1} \); \( \lambda_{o2} (\theta_{n+1} - \theta_n) \)

where:

- \( n \) - leading vehicle
- \( n+1 \) - following vehicle
- \( s \) - velocity
- \( \omega \) - radial velocity
- \( x \) - location
- \( \theta \) - angle
- \( \lambda_{o1}, \lambda_{o2} \) - parameters of sensitivity

It becomes necessary to classify the various activities at an intersection according to the type of disturbance they create. Any situation that is different from the normal flow of travel is termed a disturbance and is defined in terms of stimulus and sensitivity. Table 1 summarizes the various definitions proposed. The present study deals extensively with two types of manoeuvres only; type 1 - following vehicles and type 3 - turning vehicles. It would be possible to extend and continue this line of research in developing and calibrating models for the other types of disturbances.

The suggested form of the complete expression for the motion of two following vehicles becomes:

\[
(a_{en+1}) = \lambda_{o0} + \lambda_{o1} (x_{n+1} - x_n)^{-1} (s_{n+1} - s_n) + \lambda_{o2} (\theta_{n+1} - \theta_n) (\omega_{n+1} - \omega_n)
\] (2)
Table 1: Proposed stimulus and sensitivity terms for various traffic conditions

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Stimulus</th>
<th>Description of disturbance</th>
<th>Flow condition</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda_{ol}(X_{n+1} - X_n)^{-1}$</td>
<td>$S_{n+1} - S_n$</td>
<td>following vehicle disturbed by first vehicle going straight ahead.</td>
<td>Platoon disturbance</td>
<td>1</td>
</tr>
<tr>
<td>$\lambda_{ol}(\theta_{n+1} - \theta_n)$</td>
<td>$\omega_{n+1} - \omega_n$</td>
<td>Turning vehicle disturbance by first vehicle turning left or right</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda_{ol}(Y_{n} - Y_{S})^{-1}$</td>
<td>$(y_n - Y_S)^{-1}$</td>
<td>Vehicle on major road disturbed by waiting vehicle on minor road</td>
<td>Minor road-waiting vehicle disturbance</td>
<td>4</td>
</tr>
<tr>
<td>$\lambda_{ol}(X_{n} - X_{S})^{-1}$</td>
<td>$(y_n - y_S)^{-1}$</td>
<td>Vehicle on major road disturbed by vehicle exiting from minor road</td>
<td>Minor road emerging vehicle disturbance</td>
<td>5</td>
</tr>
<tr>
<td>$\lambda_{ol}(X_{n} - X_p)^{-1}$</td>
<td>$(y_n - y_P)^{-1}$</td>
<td>Pedestrian crossing the road disturbs vehicle's flow</td>
<td>Pedestrian disturbance</td>
<td>6</td>
</tr>
</tbody>
</table>

Terms:
- $\lambda_{ol}$: Sensitivity
- $X_n$: Position of vehicle
- $S_n$: Speed of vehicle
- $\theta_n$: Orientation
- $\omega_n$: Angular velocity
- $Y_n$ and $Y_S$: Positions
- $y_n$ and $y_S$: Lateral distances
- $X_p$: Pedestrian position
- $X_{n+1}$ and $X_{S}$: Headway
- $\theta_{n+1}$: Orientation
- $\omega_{n+1}$: Angular velocity

Constants:
- $\lambda_{ol}$ and $\lambda_{o2}$: Model coefficients
- $X_n$, $S_n$, and $\theta_n$: Vehicle properties
- $Y_n$, $y_n$, $X_p$, and $y_P$: Reference positions
- $\omega_{n+1}$ and $\omega_n$: Angular velocities
- $X_{n+1}$ and $X_S$: Headways
Most car-following models do not contain a free term like \( \lambda_{oo} \). However, as there are possibly many other factors determining the following vehicle's behaviour, such a term may not be unreasonable. The term has considerable significance in this study because the free term will be used in the determination of irregular or exceptional events. This term expresses the unexplained fluctuations in the motion of a pair of vehicles. Therefore, any reaction which exceeds the value of the free term in our model may be termed an exceptional manoeuvre. Such a reaction, caused in some way by the stimulus, may be the unusual event, the 'near accident' creating the deficiencies in the traffic and safety situation one is trying to isolate and study.

DEFINITION OF AN IRREGULARITY AND A NEAR ACCIDENT

It now becomes necessary to make a clear distinction between the flow of normal events, as predicted by the flow equation and the irregular events or near accidents. In many conflict studies, this distinction is based on observer evaluation, but in this study, it is attempted to introduce a quantifiable definition, which is to a large extent objective.

The definitions will be based on a number of assumptions:

1. Under undisturbed travel conditions, the values of the terms explained in the flow equation are equal to zero.

2. Other unexplained terms exist, whose value in the flow equation is \( \lambda_{oo} \).

3. \( \lambda_{oo} \) is the average of \( \lambda_{oo1} \) for individual pairs of vehicles, and can be regarded as the average value for a certain type of manoeuvre.

4. Under normal flow conditions, the reaction equals the unexplained term \( \lambda_{oo} \).
5. As reference value for the unexplained term \( \bar{\lambda}_{oo} \) will be taken.

6. An irregular event will be defined where the resultant deceleration exceeds \( \bar{\lambda}_{oo} \) plus some "safety" margin.

7. The "safety" margin will be based on the standard deviation of \( \bar{\lambda}_{oo} \).

An irregular resultant velocity change will therefore be:

\[
| (a_{e})_{L} | > \bar{\lambda}_{oo} + K\sigma
\]

where:

- \( (a_{e})_{L} \) - critical value of resultant velocity change.
- \( K \) - number of standard deviations.
- \( \bar{\lambda}_{oo} \) - average of free terms in equations of pairs of following vehicles (absolute values).
- \( \sigma \) - standard deviation of free terms.

As the reaction in dangerous situations is generally in terms of deceleration, equation 3 can be written:

\[
( - a_{e} )_{L} > \bar{\lambda}_{oo} + K\sigma
\]

In order to bring out those events that continue over a period of time, a further definition will be introduced that is based on the sum of decelerations. A certain critical sum value will be determined for vehicles involved in irregularities, which, when exceeded, will be termed a 'near accident'.
\[- \sum_{1}^{F} a_e > (- \sum a_e)_L \]  \hspace{1cm} (5)

where :

\[- a_e > (- a_e)_L \quad \text{for each film frame} \]

\[(- \sum a_e)_L \quad \text{sum critical value of decelerations} \]

On the basis of these criteria, determined for each intersection, 'near accidents' will be selected; their exact location within the intersection will be identified, and possible explanations will be discussed.

**STUDY METHOD**

This section will be very brief, since most details have been presented in the paper presented to the previous workshop.

Two urban intersections were filmed, using a Bolex H16 16 mm. film camera at a rate of 24 fps. The intersection area and the approach were marked with an orthogonal grid of 1 x 1 m. stripes. The film was analyzed using a Hadland Vanguard film analyzer, and in order to translate the film perspective to real coordinates, a polynomial regression of the coordinates was undertaken.

For each individual vehicle, the following values were calculated: tangential velocity and velocity change, vehicle angle, angular velocity and velocity change, resultant velocity change.

For each pair of vehicles, a flow equation was calculated by means of regression analysis. Because of the delay between stimulus and reaction, various reaction times were assumed, and for each vehicle pair that equation was chosen which produced the highest correlation coefficient.
Two urban unsignalized intersections were selected, having fairly similar and intermediate traffic flows. Each had a major road of 11–12 metre width. One, an intersection on Herzl street in Tel Aviv, was an X-type crossroad. It had had 24 injury accidents in four years, had unmarked lanes, no pedestrian crossings, and a limited field of vision. It will be termed intersection A in this paper. The second intersection, on Modiin street in Ramat Gan, intersection B, was of a T-type with only 9 injury accidents in four years, well marked, with zebra crossings and a clear field of vision. About 139 vehicles were filmed on intersection A and about 208 vehicles on intersection B, resulting in the analysis of some 60,000 film frames.

RESULTS

For each pair of vehicles travelling through each of the two intersections, motion equations were computed. For each of the two manoeuvres, travelling straight through the intersection - type 1 and turning into the side road - type 3, a general motion equation was calculated of the form

$$\ddot{a} = \lambda_{oo} + \lambda_{ol} \Delta s/Hd + \lambda_{o2} \Delta \theta \Delta \omega$$

(6)

where:

$$\Delta s = s_{n+1} - s_n ; \quad Hd = x_{n+1} - x_n$$

$$\Delta \theta = \theta_{n+1} - \theta_n ; \quad \Delta \omega = \omega_{n+1} - \omega_n$$

Results are presented in Table 2.
Table 2: Coefficients of motion equations at two intersections studied.

<table>
<thead>
<tr>
<th>Values of coefficients</th>
<th>Intersection A</th>
<th>Intersection B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>type 1 - straight ahead</td>
<td>type 3 - turning veh.</td>
</tr>
<tr>
<td>( \lambda_{oo} )</td>
<td>0.2116</td>
<td>0.2352</td>
</tr>
<tr>
<td>( \lambda_{o1} )</td>
<td>6.2538</td>
<td>5.8845</td>
</tr>
<tr>
<td>( \lambda_{o2} )</td>
<td>0.0034</td>
<td>-0.0025</td>
</tr>
<tr>
<td>( r )</td>
<td>0.87</td>
<td>0.82</td>
</tr>
<tr>
<td>stand.error S.E.</td>
<td>0.41</td>
<td>0.61</td>
</tr>
<tr>
<td>no.of data points n.</td>
<td>3015</td>
<td>654</td>
</tr>
</tbody>
</table>

For the type 1 manoeuvre, i.e. vehicles travelling straight ahead through the intersection, the values of the free coefficient \( \lambda_{oo} \) and the coefficient of the tangential motion are about twice as high for intersection A as those for intersection B. This must be the result of much more manoeuvring at that intersection, which, as may be remembered, was a cross-road with much more disorder and accidents. The coefficient for the directional motion is much lower in both cases, but was higher at intersection B. This may be a result of the higher approach speeds at that intersection or a result of differences in geometry.
The equations for the type 3 manoeuvres - turning vehicles show some similarity with the type 1 manoeuvre for the free coefficient and the coefficient for tangential motion, but the coefficients for the directional motion are negative for each intersection. This means that an increase in stimulus leads to a decreased reaction. This seems natural, since for turning vehicles a change in direction does not normally necessitate a large reaction.

Analysis of the individual motion equations for vehicles travelling straight ahead revealed that their correlation coefficients were all above 0.7 with a S.E. lower than 0.1 for 80 - 90 percent of the pairs. The tangential term was statistically significant in 90 percent of the equations and the directional term in 80 percent (at the 5 percent level). This proves that both terms are significant and provide a contribution to the explained deceleration. The free term \( \lambda_{oo} \) was different from zero in 88 percent of the cases (at a significance level of 10 percent). The equation of motion was selected in order to give the highest correlation assuming a series of reaction times. The average reaction time was found to be 1.07 seconds with a standard deviation of 0.63 seconds.

THE IRREGULAR EVENT AND THE NEAR-ACCIDENT

On the basis of eq. 4, and assuming a value of \( K = 2 \), i.e. two standard deviations, the various critical values of resultant deceleration \( (a_e)_L \) were calculated. They were 1.63 m/sec.\(^2\) for intersection A and 1.26 for intersection B. These are the limiting values indicating an irregular event and will be studied further. It cannot be said that these values all indicate an emergency or dangerous manoeuvre, but they define the border between usual and unusual or irregular events. According to these values it is now possible to identify vehicles which exceeded these values of resultant deceleration, and it may be said that these are
vehicles associated with some deficiency in the traffic or safety situation. The following table presents the number and percentage of such vehicles.

Table 3: Number and percentage of vehicles exceeding critical value

<table>
<thead>
<tr>
<th></th>
<th>Intersection A</th>
<th>Intersection B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total vehicles observed</td>
<td>139</td>
<td>208</td>
</tr>
<tr>
<td>Exceeding critical value</td>
<td>103</td>
<td>74</td>
</tr>
<tr>
<td>Percentage exceeding</td>
<td>74.1</td>
<td>35.6</td>
</tr>
</tbody>
</table>

The percentage of vehicles involved is large, particularly at intersection A. It should be emphasized that all vehicles which produced a value exceeding the critical value (even in one frame only), are here included.

A further distinction will now be made, based on eq. 5, selecting those vehicles which contributed to the resultant deceleration both in value and in duration. The further separation was done with the aid of the graphs in Figure 1, on which the absolute cumulative frequency of resultant deceleration is plotted for each intersection. The decision on some critical value – $L_2$ – resulted in the exclusion of those many vehicles which contributed relatively little to the resultant deceleration. $L_2$ was chosen at the turning point of the graphs. The remaining vehicles were defined as those involved in 'near-accident' situations.

Table 4: Number & percentage of vehicles involved in near accident situations and their critical cumulative values of resultant deceleration.

<table>
<thead>
<tr>
<th>Intersection</th>
<th>No. of vehicles involved in 'near accidents'</th>
<th>Critical value of sum of decelerations $\sum (a_e)_L = \text{m/sec.}^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>number</td>
<td>percentage</td>
</tr>
<tr>
<td>A</td>
<td>22</td>
<td>15.8</td>
</tr>
<tr>
<td>B</td>
<td>16</td>
<td>7.7</td>
</tr>
</tbody>
</table>
Fig. 1: Distribution of sums of resultant decelerations of vehicles for critical values.
These vehicles contributed 49 percent of the total sum of deceleration in irregular manoeuvres at intersection A and 75 percent at intersection B.

A further study can now be made as to the type of manoeuvres that contributed to the 'near-accident' situations, and what critical values were associated with each type.

Table 5: Number of vehicles involved in near-accident situations and their sum of resultant decelerations - by type of disturbance

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Parking &amp; platoon</th>
<th>turning to minor road</th>
<th>waiting in minor road</th>
<th>exit from minor road</th>
<th>pedestrian</th>
</tr>
</thead>
<tbody>
<tr>
<td>N [\sum a_e]</td>
<td>N [\sum a_e]</td>
<td>N [\sum a_e]</td>
<td>N [\sum a_e]</td>
<td>N [\sum a_e]</td>
<td>N [\sum a_e]</td>
</tr>
<tr>
<td>A</td>
<td>-</td>
<td>4</td>
<td>331</td>
<td>2</td>
<td>158</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>33</td>
<td>3</td>
<td>144</td>
<td>1</td>
</tr>
</tbody>
</table>

N - number of vehicles  
\[\sum a_e\] - sum of resultant decelerations (m/sec.\(^2\))  
F - No. of frames

It is seen that the exit from the minor road is clearly both the most numerous and except in one case, the heaviest contributor to the resultant deceleration. At the two intersections studied, pedestrians are also a major source of risk. Third in importance is the turning manoeuvre into the side road.

A further evaluation of the various manoeuvres will now be attempted according to three types of groupings.
IDENTIFICATION OF COMPOSITE NEAR ACCIDENT SITUATIONS

In many traffic events, including accidents, a number of vehicles are involved. The influence of a disturbance such as a crossing pedestrian or a turning vehicle is therefore, in many cases, felt on more than one vehicle. In this section, vehicles have been grouped according to one composite event and the resultant deceleration studied.

Table 6: Number of composite 'near accident' situations and their sum of resultant deceleration — by type of disturbance.

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Vehicle exiting or waiting in minor road</th>
<th>Vehicle turning to minor road</th>
<th>Pedestrian</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.of events</td>
<td>sum decel.</td>
<td>No.of events</td>
</tr>
<tr>
<td>A</td>
<td>14</td>
<td>2660</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>6</td>
<td>560</td>
<td>2</td>
</tr>
</tbody>
</table>

Again it is clearly demonstrated, both in terms of number of events and magnitude of deceleration, that the major disturbance at the two intersections is the merging manoeuvre of the vehicle from the minor road. The limited number of events presented in this table contribute some 70 - 80 percent of all the irregular decelerations.

ANALYSIS OF TYPES OF DISTURBANCES

Each vehicle passing through the intersection was classified according to the disturbance created. Previous sections dealt with those vehicles involved in near accident situations. A further study will now be made of the disturbances according to their impact on various indices of resultant deceleration. All vehicles involved in irregular events, as described in Table 2 were included.
Five different terms of resultant deceleration have been calculated:

1) The sum of the resultant decelerations of all vehicles involved. This indicates the total level of reaction.

2) The average resultant deceleration per vehicle. This presents the average reaction, giving equal weight to each film frame.

3) The average resultant deceleration per frame, presenting the average reaction per vehicle again with equal weight to each frame.

4) Sum of average resultant deceleration per vehicle, presenting the sum reaction per vehicle involved in an irregular event with equal weight per vehicle.

5) Average of average resultant decelerations per vehicle, presenting the average reaction per vehicle involved in an irregular event, with equal weight per vehicle.

Table 7 summarizes the results for the five expressions and the various disturbances.

The most marked disturbance per vehicle involved is that of a pedestrian crossing the road. Apparently, this disturbance creates the most extreme reactions. The disturbance of vehicles emerging from the minor road is most felt in the sum expressions (1) and (4), but is also considerable as average per vehicle.

These tendencies can be found back in the accident data for the two intersections, and in accident data at urban intersections in Israel in general.
Table 7: Sums and average values of resultant deceleration in various traffic disturbances at each intersection

<table>
<thead>
<tr>
<th>Intersection B</th>
<th>Intersection A</th>
<th>Type of disturbance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td>(4)</td>
<td>(3)</td>
</tr>
<tr>
<td>F N 7/3 e 1 N 1 F-2</td>
<td>F N 7/3 e 1 N 1 F-2</td>
<td>F N 7/3 e 1 N 1 F-2</td>
</tr>
<tr>
<td>0.2</td>
<td>10.4</td>
<td>1.5</td>
</tr>
<tr>
<td>0.3</td>
<td>7.1</td>
<td>1.4</td>
</tr>
<tr>
<td>0.5</td>
<td>16.4</td>
<td>1.5</td>
</tr>
<tr>
<td>0.5</td>
<td>14.7</td>
<td>1.8</td>
</tr>
<tr>
<td>0.5</td>
<td>14.2</td>
<td>1.8</td>
</tr>
<tr>
<td>0.6</td>
<td>10.1</td>
<td>1.5</td>
</tr>
<tr>
<td>1.2</td>
<td>26.1</td>
<td>2.0</td>
</tr>
<tr>
<td>1.6</td>
<td>16.0</td>
<td>2.1</td>
</tr>
</tbody>
</table>
Table 8: Number of accidents by type – 1972 – 1975

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Pedestrian involved</th>
<th>Front to side</th>
<th>Rear end</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
<td>14</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 9: Distribution of accidents at urban intersections in Israel during 1972. Percentages by type of accident.

<table>
<thead>
<tr>
<th>Type of accident</th>
<th>Pedestrian involved</th>
<th>Front to side</th>
<th>Rear end</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of all accidents</td>
<td>25.9</td>
<td>46.4</td>
<td>8.3</td>
<td>19.4</td>
</tr>
</tbody>
</table>

A further study of the two intersections by sum and average of decelerations of all vehicles also clearly shows that on all accounts, intersection A has much higher reaction values than intersection B, and is clearly deficient.

BLACK SPOT LOCATIONS AT THE INTERSECTIONS

In accident analysis it is usual to try and identify black spots in order to treat them for improvements. A similar attempt can be made in this study, trying to identify irregular events and associate them with certain features of the intersection. The 'black spots' are those locations at the intersection which had high concentrations of irregular decelerations. For each 1 x 1 m. square of the intersection, the sum of resultant deceleration of vehicles involved in irregular events \( > |a_{e,L}| \) was calculated, the assumption being that a location with high values may indicate a location with increased risk, and therefore worth investigating. A map of 'iso-manoeuvres' has been prepared for each intersection. The dark areas are those with high values of deceleration. The lighter the areas, the less disturbance they experience. Figures 2 and 3 present the results.

Intersection A – the crossroad experiences a much higher level of disturbance than intersection B.

At intersection A, the black areas are located at the entrance to the intersection area, whereas at intersection B, they are located at the exit and on the approach.
Fig. 2: Iso-manoeuvre areas at Herzl-Kibbutz Galuyot intersection, all vehicles.
Fig. 3: Iso-manoeuvre areas at Modiin-Hibat Zion intersection, all vehicles.
These results can be explained by the differences between the intersections. Intersection A, being a crossroad, vehicles crossing on the minor road cause decelerations to vehicles on the major road at the entrance to the intersection area. Intersection B, being a T-junction, merging vehicles turning left into the major road create a disturbance at the exit of the intersection area. A further area with difficulties is notable at intersection B on the major road approach, caused by left-turning vehicles on the major road. This is reasonable when pointed out that this intersection does not have a left-turn lane.

It can be concluded that a microscopic analysis of the vehicle manoeuvres can lead to an identification of those intersection locations which have a high concentration of decelerations. Various ways of improvement can then be suggested.

SUMMARY AND CONCLUSIONS

This study has presented a quantitative definition of the near accident concepts, and of the level of risk associated with various types of manoeuvres at an intersection. The definition is objective and is not influenced by observer variations. The definition is based on the development of two dimensional equations of motion for vehicles traveling through the intersection, the calibration of such equations, and on the definition of critical values of resultant deceleration. The method needs relatively high speed continuous filming of the intersection area, and necessitates a detailed film analysis. This method could supplement existing methods of conflict analysis techniques in providing an objective measure to which one could compare various methods of subjective observer evaluation.

It has been shown that the vehicle motion through the intersection can be objectively and consistently described by a two-dimensional motion equation.
The various types of disturbances generally encountered at intersections have been evaluated in terms of these motion equations, and near-accident situations have been defined.

The method is also useful in determining specific trouble locations within the intersection area.

The two main shortcomings of the method are:

1) The amount of work involved. This amount of work makes the method almost impractical for engineering purposes. It does, however, provide an excellent analytical tool for an improved understanding of the complex vehicle interactions at intersections.

2) The near accident concept developed is dependant on the establishment of specific estimates for each intersection studied. A large amount of data on many more intersections is therefore needed before one could produce conclusive and general levels of risk.

REFERENCES
