Traffic Study Technique at Rural Intersections, by U Linde­roth and L Ringhagen, National Swedish Road and Traffic Research Institute (VTI).

1. Introduction

Since the later half of 1976, National Swedish Road and Traffic Research Institute (VTI) has been working with a development of a traffic study technique adapted to rural intersections. The primary aim is to receive knowledge of accident producing mechanisms working at intersections.

The traffic flow in the majority of the rural road net­work intersections in Sweden is not especially high and therefore we have not designed our investigation as an ordinary traffic study with intentions to measure what usually is meant by traffic conflicts, e.g. traffic situations classified as "near accidents". In the following text, the concept of traffic measurements includes traffic conflicts in ordinary sense as well as situations with low potential for accidental risks.

Definitions of traffic measurements

Conflicts, operationally defined by occurrence and serious­ness of the corresponding overt conflict solution, are - specially the serious ones - very rare events in rural areas according to our opinion, based on screening a sub­stantial amount of videotaped traffic situations. In order to define measurements which can be assumed to be related to traffic conflicts, but more informative than e.g. simple flow variables, we have looked for more com­prehensive traffic measurements, some of which are exempli­fied below.

The vehicles, observed in different traffic streams at an intersection, are grouped together according to certain time criterias. Within every group, the vehicles belonging to the main stream, are ordered in pairs. For such pairs we define a leading and a following car by use of arrival time at first passage.

The high accuracy of estimated coefficients in the func­tions which describe individual trajectories makes it possible to use different measurements and to follow intra­traffic relations in every combination of cars in terms of differences in position, velocity and accelera­tion.
We will give some examples of such intra-traffic relation measurements. For two cars, belonging to the main road stream we could have a situation like that in figure 2 with an observed "rear-end" situation. We introduce a simulated sudden stop for the leading car at some instant. After some time, equal to the reaction time of following car, we simulate a response-trajectory corresponding to an avoidance maneuver defined as a heavy deceleration. If the hypothetical collision, will be a fact or not, depends on the relations between the trajectories and the point of time for the simulated sudden stop. The critical moment in that respect gives for every pair of cars a "minimal safety distance" (MSD). We define a MSD-phase with help of observed time and road position for the leading car, which is the conflict generating element. The definition should be clear from the figure. The MSD-phase is terminated when approaching condition is changed, i.e. when passing occurs.

In the example above, the velocity of the leading car was drastically changed to zero. Another case could be a situation where the leading car retained its velocity but though a lane-shift prevented an initiated passing process. (figure 3.) We introduce the concept of "point of no return" (PNR). If the following car isn't able to adapt to the new condition, we will say that it has passed PNR. As in the MSD-example, we can define a PNR-chase. This concept is somewhat more complicated. Road position is not, as for MSD, the same for the generative event and the corresponding consequence. The MSD-phase has two parts, one generative and the other consecutive (look at the figure).

If we are interested in the conflict-generative properties of an intersection we would study the generative part of PNR. If we on the other hand are interested in a comparison with accident outcome we should concentrate on the consequence part.

The passing process itself can be divided into subsequent parts defined e.g. by positional relations like "leading car back to following car front", "side by side" and "leading car front to following car back". For each state we than estimate initial and terminal road positions and duration.

Relations between the left turning main stream and the oncoming traffic is of course of great importance. We have here classified observed interactions according to a disturbance category scheme.
A short list of output measurements

For individual cars:

1. Direction (traffic stream category)
2. Type of vehicle
3. Trajectory parameters
4. Position
5. Velocity at relevant points of time
6. Acceleration
7. Durations in intersection parts

For relations in combinations of cars:

1. Direction combination
2. Type combination
3. Distance between cars
4. Relative velocity at specific points of time
5. Relative acceleration
6. Total time in the intersection for cars
7. Common time in different parts
8. Initial and terminating positions for different phases
9. Corresponding durations
10. Disturbance categories
11. Passing categories

2. Method of traffic measurement

Information of the traffic process has been obtained by way a video tape recordings-method. In a first step we have collected data from about 10 rural intersections, corresponding to about 50 hours effective recordings of traffic (approximately 5 000 observed cars).

The general design is demonstrated in figure 1. The actual intersection together with a portion of about 100-150 meters of the connected main road are covered by 4 video cameras. By painted markings on the road the investigated area is divided in relevant sections. The video system includes a time generator and so we can estimate passage times between those sections. From the recordings we get informations about direction, type and sideposition.
Our main interest has been focused on the left turning traffic and its interaction with other potentially conflicting streams. The observation team has selected those situations for recording, which include at least one left turning car. According to some criteria, based on time assumed to be sufficient enough to not imply interactions between the left turning cars and other traffic streams, groups of cars have been formed.

3. Systematic and random errors

A great amount of work has been used to develop estimation methods with the purpose to reduce the influence of random errors and to correct for systematic errors. For systematic errors, e.g. road distance errors, we use a method for correction based on estimation of the car velocity in two different ways and then comparing these values for a small sample of our recorded cars.

After correction for systematic errors we still have to take random variation into consideration. In spite of efforts to make accurate readings of passage times we have had some problems with disturbing influence of random nature. As the reliability of our difference measures is very sensible to that fact, we have used an approach based on a regression model with a polynomial of somewhat less degree than what could optimal be used regarding number of observations. Thus, we are smoothing out the initially observed course, but still expect our model function to allow most forms of true variations. Thus, for every car in the primary direction of the main road we estimate 4 regression coefficients, which in the following analysis are used to compute road positions, velocities and accelerations at every requested instant. In one of the checking programs we have a method based on the sum of squared residuals.
FIG. 1 GENERAL OBSERVATION DESIGN
FIG. 2 THE CONCEPT OF MINIMAL SAFETY DISTANCE (M.S.D.)
FIG. 3  THE CONCEPT OF POINT OF NO RETURN (PNR)