SAFETY ANALYSIS OF THE TRAUTENFELS JUNCTION

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1. Background

The analysis offered here is based on observations made at the site during September 12-15, 1985. During that period, we recorded certain basic traffic characteristics, noted potential hazards due to the particular geometry of the junction and land use around it, and measured selected traffic behaviors potentially indicative of collision risk. Our observations were, necessarily, limited in their extent and cannot be considered completely representative of the traffic situation at the junction. Speed measurements were carried out with a hand-held radar "speed-gun". All other observations and counts were performed manually. At a later date, we were supplied with traffic characteristics data collected at the site by the Austrian team. These data were more extensive than those we had collected and therefore were used in our analysis. Whenever a comparison was possible, our counts match well with the Austrian counts and speed measurements.

The Austrian data, too, were limited to the study's four day period and specific hours, and we do not know how representative they are of other periods.

We also classified the 165 conflicts recorded by all the other teams during the study and related them to our findings.

The Trautenfels junction was described to us as an accident-prone site, yet we were given no imformation about the number of such accidents and their nature until after the completion of the on-site observations. As a result, the choice of locations, traffic characteristics, and traffic behaviors observed during the field study was not guided by the hindsight acquired through the knowledge of the accidents. This has some methodological advantages, as well as practical shortcomings.

We complete our safety analysis of the junction with a look at the distribution of accidents at the site during 1984, and relate them to traffic characteristics, to traffic behaviors and to conflicts observed. It should be noted that one year's accident record might not be a reliable representation of the consistent safety problems at the site, especially if (as we were told) significant engineering modifications to the junction control were carried out during early 1985.

2. Traffic Characteristics

Following the suggestion of the Austrian coordinator of the study, we assumed that most of the safety problems at the junction are related to the movement of traffic on the national road connecting Salzburg and Liezen (Roads B146 and B308). Therefore, most of the counts and observations focussed on the through traffic approaching the junction from Liezen on road 308, and from Salzburg or Schladming on road 146.

2.1 Traffic volumes

Table 1 summarizes hourly traffic counts during various days in the study period, supplied by the Austrians.

Time \ Road	146	308
10-11	200	417
11-12	222	387
16-17	277	474
10-11	176	397
14-15	333	595
09-10		507
14-15	351	683
10-11	272	692

The peak hourly volume on 308 can be estimated at 600 v/hr and the corresponding number for 146 is 300 v/hr. The peak hourly volume at the other two approaches combined was estimated at 300 v/hr. Assuming that the peak hour-volume represents 15% of the daily traffic, it can be estimated that the ADT on 308 was 4000, on 146 - 2000, and likewise on 145+75

The ADT at the junction may be estimated in the order of 10,000 ADT.

Traffic counted from road 308 was double that from road 146. We assume that during the year this pattern changes with seasonal and holiday variations and therefore the AADT (Annual Average Daily Traffic) of the junction is indeed about 10,000 and fairly balanced in both directions.

2.2 Vehicle speeds

Spot speeds of free flow traffic approaching the intersection during the green phaze indicate essentially similar speed distributions on both main approaches: $\overline{V}$ = 60 k/m ± 8.0 S.D. The median is slightly lower and the 85th percentile is 72 km/h. Independent speed measurements carried out by us, closer to the intersection, tie in well with these results.

As expected, hourly speeds vary by about 5%, depending on traffic density, time of day and other situational factors.

2.3 Traffic composition

Two obvious ways by which vehicles at the junction could be classified were vehicle type and vehicle's country of registration. In our counts, the proportion of trucks coming from Road 146 was 16%, compared to 30% on Road 308. The other vehicles were mostly private cars or small vans. As many of the trucks were long-haul trucks making cross-national trips, we expect the proportions to vary considerably with business days, season and time of day. We also expect that over the year, the ratio of trucks on the two main approaches is balanced out.

A full half of the vehicles passing through the main approaches of the intersection were non-local origin, as judged by their license plates.

A further breakdown of non-local traffic according to driver characteristics-guest workers and others- is possible from the speed data supplied by the Austrians. From these data, it can be seen that guest workers are about 50 percent of the non-local private car traffic on the main road. Large fluctuations do exist, however, in the various proportions of drivers and more extensive counts are required to obtain reliable estimates.

Vehicle speed distributions provided by the Austrian team, broken down by drivers' apparent origin (local Austrian, foreign, foreign-guest workers) indicate no appreciable difference in mean speeds between local Austrian and foreign drivers and somewhat lower approach speed by the guest workers. The standard deviations were also similar. Our impression from the site was that vehicles driven by guest workers were typically larger, of older vintage, were fully occupied and loaded, travelled in convoys and consequently travelled at lower speeds.

3. Junction Geometry and Control Devices

We do not have the data for a detailed engineering evaluation of the junction in terms of level of service provided by the geometry, control devices, pavement and roadside treatment. On the face of it, and given the traffic volumes and the approach speeds, the junction accommodates cross-flows of traffic quite smoothly.and solutions were provided for all obvious traffic movement needs.

However, since accidents are known to have occurred at the junction in relatively large numbers, we observed and noted potential hazards associated with the junction's design.

3.1 Turning lane from Road 308 to Road 145

This right turn lane carries fast traffic which can disregard the traffic light at the junction; vehicles turning right do not have to slow down appreciably because of the large turning radius and because they have the right of way on merging to Road 145. When vehicles on Road 308 going through queue up on the approach to the junction or slow down because of the signal, the turning lane can be blocked and the differential speeds between turning and through traffic create a hazard.

3.2 Priority rules at the merging point on Road 145

Vehicles turning right from Road 308 have the right of way over traffic going straight to Bad Ischl on Road 145. While this reversal of the usual procedure is probably justified at this location, it might create a hazard if drivers unfamiliar with the location act according to established tendencies. i.e. slow down on the right turn lane (thus creating a risk of rear end collision) or ignore the yield, going straight on to Road 145 (and risk a side sweep or rear end in the merge area).

3.3 Shopping centers

The two shopping areas on Road 308 and on Road 145 are very close to the junction and therefore constitute a potential hazard because of entering and exiting vehicles in a relatively fast traffic environment.

3.4 View obstructions

The guardrail and other structures on the refuge island linking Road 75 and 308 obstruct the view to drivers of vehicles merging right into Road 308. Lack of an acceleration lane and the proximity of the petrol station make this maneuvre a potential hazard. The corresponding right merging from 145 to 146 appears to be less of a problem, except that vegetation growth (or show piles) on the refuge hinder visibility.

3.5 Junction coherence

The junction has a somewhat staggered appearance to drivers coming from Road 145 and Road 75 because the two median islands are offset. This might lead to some confusion or inappropriate vehicle positioning during turning and going through the intersection. Obstruction by large trucks might restrict drivers' perception of the intersection, thus contributing to a misplaced path choice by affected vehicles.

3.6 Traffic signals

The signal program for the junction provides the same green phase and clearance, and intergreen intervals for movement on the main approaches, thus treating both approaches as symmetrical. The intergreen is 5 seconds amber.

The sight distance for drivers approaching from Road 146 is shorter than for drivers coming from Road 308. Road 146 goes through a wooded area and coming out of a curve, the drivers are faced with a junction, signals and a built up area that looks unexpectedly complex. Drivers coming from Road 308, on the other hand, enter the built-up area earlier and see the junction from a larger distance.

If apparent differences in appearance are large enough, they might be reflected in different deceleration patterns and different stopping/crossing tendencies, requiring different intergreen intervals for each approach (or a larger one for both). An insufficient intergreen interval might lead to right-angle and left turn type collisions.

The other potential hazard related to traffic signals is the use of flashing green during the last 3 seconds of the green phase. This practice was shown (1) to extend the indecision zone and to increase considerably the frequency of rear-end type collisions. The 5 seconds amber with overlapping amber on conflicting directions is also considered too long and hazardous.

So far, the analysis of the junction's traffic characteristics revealed volumes and speeds quite in line with the size of the junction and about the same on both main approaches. We noted traffic composition with respect to proportion of trucks and proportion of non-local drivers. Junction geometry and control devices suggested a number of potential hazards at turning and merging points, at left turns with opposing traffic, near shopping centers and with respect to the flashing green operation. Many of the hazards pointed out would tend to produce rear-end type collisions.

4. Traffic Behavior

In order to verify some of our observations concerning potential hazards at the junction, we selected three of these for more detailed analysis: merging encounters, left turn encounters, and stopping behavior.

4.1 Merging encounters

As mentioned in section 3.2, merging from Road 308 into Road 145 was noted as a potential hazard because of the reversal of priority rules, and the high speeds of the merging vehicles. Merging encounters there were recorded during three different periods. An encounter was defined as an event where a vehicle merging from Road 308 had to accommodate in some way a vehicle going on Road 145 (coming from Road 75 or turning left from Road 146) or vice versa. The total number of passing vehicles was also recorded. Similar counts were made at the merging point of Road 145 to Road 146.

Table 2a: Merging encounters on Road 145

Period	No. of vehicles merging from 308 - V1	No. of vehicles on 145 - V2	Product of converging volumes V1xV2	No. of encounters	Ratio of encounters
15.45-17.00	158	94		13	
10.05-10.45) 11.15-12.30)	259	113		19	
60 min. average	156	78	12,168	12	1:1000

Table 2b: Merging encounters on Road 146

Period	No. of vehicles merging from 145 - V1	No. of vehicles on 146 - V2	Product of converging volumes V1xV2	No. of encounters	Ratio of encounters
9.10-10.30) 11.10-12.00)	78	not counted		22	
60 min. average	36	500 (est.)	18,000	10	1:1800

Table 2a shows that the ratio of passing vehicles was 2:1 in favor of the merging lane with the right of way. On the merging lane, from Road 145 to Road 146, on the other hand (Table 2b), the ratio was 1:15 in favor of the through road. The table also displays the product of the converging volumes (V1, V2), which is often used as a measure of exposure. The product is almost twice as large for the merging into 146 as for the merging into 145. The number of encounters observed at the two merging points was rather similar. Thus, the ratio of encounters to the product of the converging volumes is smaller at the merging with Road 146 than with Road 145. This ratio is probably affected by the distribution of volumes, but it may also express an overall engineering quality of the merging arrangements given the converging volumes and the potential for contacts. Implicit and explicit clarity of rights of way at the merging area or preview distance afforded to the merging driver are examples of factors that might affect the ratio. Observations of drivers' overt looking behavior at the merging to Road 145 showed that 35% of the drivers, in each direction, appeared not to be looking at the direction of potential vehicles merging from the other road. At the merging into Road 146, 90% of the vehicles stopped or slowed down and even those drivers who appeared to merge without slowing had clearly looked in the direction of the oncoming traffic. The marked difference in drivers' looking behavior may reflect differences in geometry, preview distance and right-of-way rules, which also affect the ratio of encounters to product of volumes.

4.2 Left turn encounters

As noted in sections 3.5 and 3.6, some potential hazards associated with junction coherence and traffic signal design might be brought about during left turn maneuvers. Therefore, we observed left turn encounters on the three main approaches of the junction. (There was only little turning movement from Road 75.)

A left turn encounter was defined as an event when a left turning vehicle had to wait, stop or slow down considerably for straight-going vehicle(s) (from the opposite direction) to pass before it could complete the turn.

Table 3 summarizes left turn encounters and the corresponding straight and left turn vehicle counts. The table averages our and the Austrian team's counts during two 60 min. and one 95 min. periods.

Table 3: Vehicles/h involved in left turn encounters

Traffic condition	Direction of left turn		
	146 to 145	308 to 75	145 to 308
Opposing traffic	294	183	44
Left turn	45	65	155
Left encounters	16	18	10
Product of volumes (L.T. x opposing traffic)	13,230	11,895	6,820
Ratio of encounters to product of volumes	1:830	1:660	1:680

Table 3 shows a fairly balanced situation for the left turns from the main approaches. The number of encounters for left turns from Road 145 is smaller but the ratio of encounters to the product of crossing volumes is about the same as for the other approaches. It is also noted that many of the turning vehicles from Road 145 do so during a special green signal for left turners which operates within the Road 145-Road 75 signal phase.

The left turn and merging encounter data should preferably be interpreted with reference to similar data from other locations, in order to assess whether the absolute numbers or ratios are within an acceptable range. Such data, unfortunately, do not exist.

4.3 Stopping behavior at the onset of flashing green

As noted in section 3.6, we considered the use of a flashing green (F.G.) in the signal timing program as a potential hazard.

Analytical, laboratory, field and questionnaire data (1,2,3,4) all suggest that the onset of a flashing green triggers drivers to initiate a decision - to stop or to cross the junction - much the same as the onset of yellow where F.G. is not used. This effect, in turn, has a number of consequences: a. it extends the indecision zone (the approach distance over which the probability of stopping ranges from 10% to 90%, or any other defined range);

b. it increases the proportion of vehicles and drivers required to make a choice at the approach to the intersection;

c. it increases the proportion of vehicles stopping unnecessarily for the light;

d. it increases the apparent option zone for slower vehicles that might, consequently, enter the intersection after the onset of red light (5).

The first three effects create a situation where a higher proportion of drivers approaching the intersection are likely to make conflicting stop/go choices at the termination of the green light, thus risking rear-end accidents.

The fourth effect might produce right-angle accidents if the inter-green interval, typically calculated for the faster vehicles, is not sufficient for lower speed vehicles.

In order to study the potential effect of F.G. at the junction, we made observations of vehicles' stopping behavior on the two main approaches. Since we could not tell what the stopping behavior at the junction would be had there not been an F.G. phase, we compared the results to data from other countries and compared the two approaches with each other.

A stretch of 90 m upstream of the intersection was considered a distance within which vehicles approaching the junction might be affected by a change of signal light. It takes 6 sec. to cover this distance at a speed of 54 km/h. Out of 384 free-flowing vehicles observed on Road 308, 22% were in the 90 m zone during the change to F.G. and yellow. The corresponding figures for Road 146 are 330 vehicles and 20%.

Many of the affected vehicles were indeed observed reacting to the onset of F.G. by either accelerating (34%) or brake application (5-14%). Some of the latter changed their initial reaction and continued to cross the junction.

Fig. 1 shows the percent probability of stopping as a function of distance from the stop line for the two approaches. U.S. data from Zegeer (6) is also shown for comparison. Our data points are based on 109 and 40 vehicles approaching at various speeds; the U.S. graph is based on about 400 vehicles, driving at 55-62 km/h.

Compared to the U.S. stopping probability function derived at yellow only intersections, the F.G. graphs relate to distances closer to the intersection and cover a wider distance of an indecision zone.

Indecision zone (10%-90% probability of stopping)

	range	distance
U.S., yellow only	30 m - 72 m	42 m
Road 146, F.G.	10 m - 57 m	47 m
Road 308, F.G.	10 m - 85 m	75 m

The intersection zones at the two approaches are different. The stopping probability function on Road 146 is steeper than on Road 308, and it produces a shorter indecision zone. From a safety point of view, it is closer to the ideal step-function probability (1).

A shorter indecision zone means that there is a lesser likelihood of different drivers making opposed stop/cross decisions.

As mentioned in section 3.6, the Road 146 approach has a shorter sight distance, and drivers approaching from there are suddenly faced

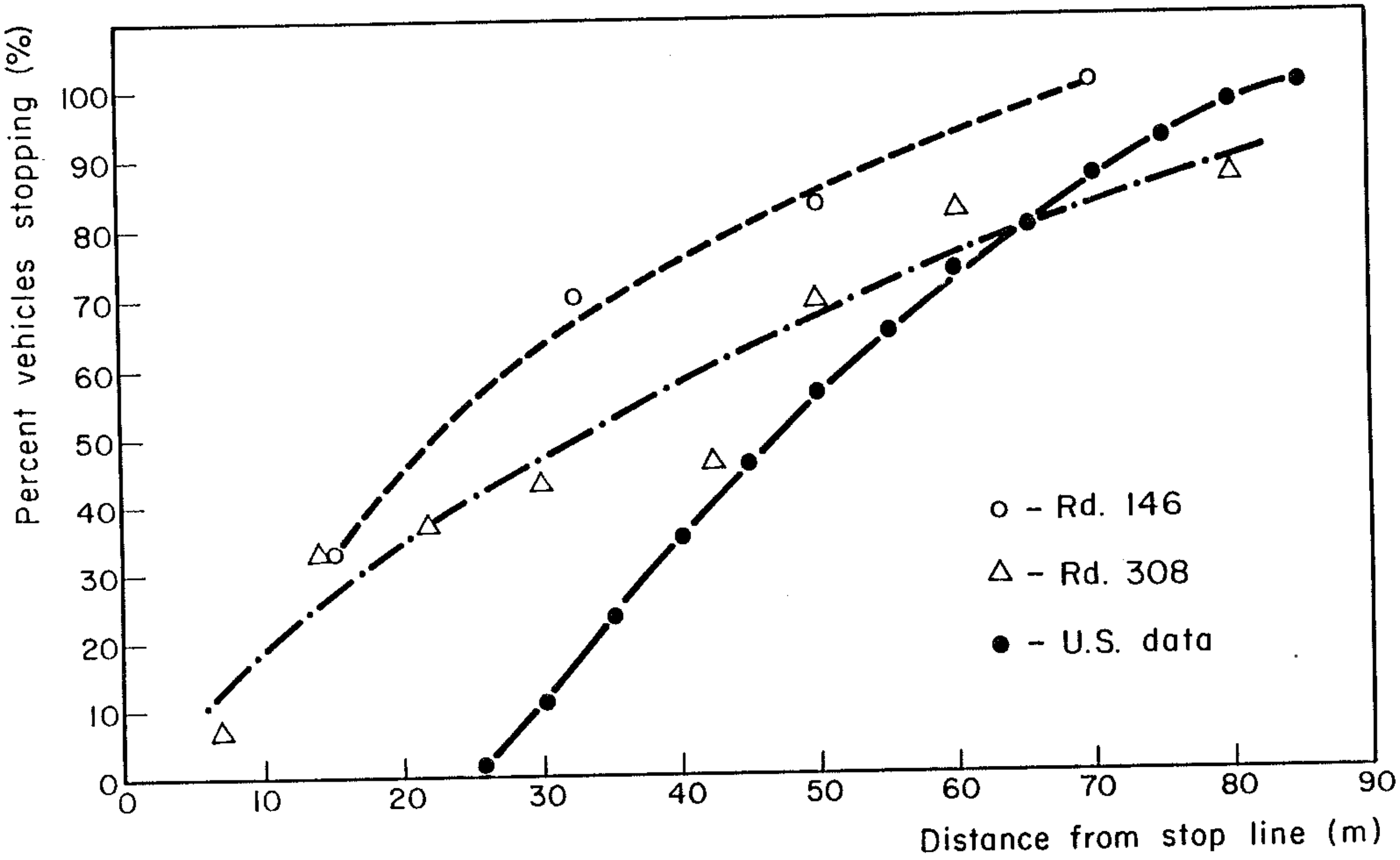

Fig. 1: Stopping probability as a function of distance from intersection stop line.

with a visually complex environment. Perhaps these factors account for the behavioral differences in the stopping probability functions and for the differences in the number of conflicts and accidents on the two approaches described later.

The traffic behavior measures we have used, which were necessarily limited, show considerable sensitivity in expressing quantitatively the hazard potential of certain traffic situations and maneuvers. Their exact interpretation in terms of hazard severity requires external reference to quantities in similar situations at other junctions. Only in the case of the F.G. do we feel that a theoretical basis and empirical external reference data from other countries provide a stronger basis for expecting a large number of rear-end collisions on both main approaches of the intersection and, perhaps, more so on Road 308. For the same reason, rear-ends can also be expected on the minor approaches of the junction.

5. Conflicts

We classified all the unique conflicts recorded by at least one team during the Trautenfels conflict observations. The classification categories and frequencies are shown in Table 4.

Each conflict was taken at face value without checking the mechanism from the video-film. Severity rating was also not considered.

This simple categorization of conflicts suggests a number of hazardous situations at the junction. Mostly, they coincide with the potential hazards described by us in section 3 (geometry and control devices) and further elaborated in section 4 (traffic behavior).

The conflict categories with a large number of conflicts can be interpreted as an indication of a particularly hazardous location - the left turns and the merging maneuvers. The rear-end conflict was not very common - 4 on Road 146 and 13 on Road 308. It should be noted that beacuse of the positioning of the observers close to the intersection, it is possible that many rear-end conflicts were not observed and recorded.

Table 4: Classification of the conflicts recorded by all teams

Front-side	1
Left turn from Road 146	28
Left turn from Road 308	9
Left turn from Road 145	14
Merge on Road 145	26
Merge on Road 146 or Road 308	16
Rear end on Road 146	4
Rear end on Road 308	13
Other*	53
	164

*Many of the "others" were rear-end conflicts on the right turning lane to Road 145.
About 10 conflicts involved weaving and lane changing on the main approaches from the left turn lane to the straight lane.

Our analysis of the indecision zones at the two approaches (section 4.3) fits the finding of fewer rear-end conflicts on Road 146 than on Road 308. The merging encounters we observed at Road 145 and Road 146 (section 4.1) also agree with the conflict data in that we noted more encounters (relative to the product of converging volumes), and more non-looking behavior on Road 145, as compared to Road 146.

Our measures of turning encounters (section 4.2) do not differentiate the three major turning maneuvers as the conflict data seem to do.

6. Accidents at the junction during 1984

6.1 General trends

Our accident analysis is based on the summary sheets provided by the Austrian team. We note that, of the 42 accidents during that year, 14 were injury accidents. We have no direct personal experience with data on PDO (Property Damage Only) accidents. According to one study in the U.S. (6), the ratio of injury accidents to total number of accidents at signalized intersections was 1:2, exactly as it was in Trautenfels.

64% of all the accidents at the junction were rear-end accidents. Many of those were PDO accidents. When only injury accidents are considered, six out of 14 (43%) were rear-end accidents. Rear-end accidents are the single largest category of accidents at the junction. This situation is also typical of collision accidents at signalized intersections in Israel, where we found 50-54% rear-end accidents in different sets of data (accidents at all 43 signalized intersections in the City of Haifa and all accidents at interurban signalized intersections in the country). Most of these intersections use a flashing green phase in their program. The proportion of rear-end accidents at signalized intersections in the U.S. is typically lower. Right angle collisions are usually the largest category of accidents.

6.2 Driver involvement, location and type

We examined all 42 accidents according to their type, location and the identity of the drivers involved, as noted in the Austrian accident summary sheets.

Table 5: Accident classification according to type, location and driver's identity

Rear-End Accidents

Road	308	146	Total - main road	145	75	Total
No. accidents	14	11	25	1	1	27
Local drivers	12	11	23-40%	2	1	26-43%
Foreign drivers	22	12	34-60%		1	35-57%

Right-Angle Accidents and Others

Road	308 145	146 145	146 75	308 75	Left turns	Others	Total
No. accidents	3	1	2	1	4	4	15
Local drivers	5	-	2	2	6	2	17-63%
Foreign drivers	1	2	3	-	3	2	10-37%

More rear-end collisions took place on Road 308 than on Road 146, and more of them involved multiple vehicles. Also, five of these accidents were injury accidents, as compared to one injury accident on Road 146. There is no clear pattern to the other types of accidents. Right-angled accidents might be related to the length of the clearance interval.

In total, foreign drivers do not seem to be involved in more accidents than local drivers. Their contribution to accidents was proportional to their share in the traffic (50% on the main road) - 45 of the involved drivers were foreign against 43 locals (Austrian). When all the accidents in which at least one of the drivers travelled on the main road are considered (Table 6), the percent of non-local drivers involved remains similar to their proportion in the traffic. Guest workers make up 65% of these foreign drivers, somewhat higher than their estimated share in the traffic.

Table 6: Distribution of drivers involved in accidents on the main approaches

	No.	%
Local	35	47
Foreign	40	53
Guest workers	26	35
Other foreigners	14	19
Total	75	100

Foreign drivers were more likely to be involved in rear-end type accidents, rather than other accident types (Table 5). The proportion of foreign drivers involved in rear-end accidents on the main road is 60%, slightly higher than their proportion in the traffic. About three-quarters of these foreign drivers were guest workers.

A study of accidents during September 1984 compared with traffic flows measured in the study is rather unreliable. Six accidents with drivers on the main roads occurred during September. Of these, a larger proportion involved guest workers (57 percent) than their share in the traffic volume measured. Much more comprehensive traffic counts are needed to substantiate these limited findings. We tested the possibility that perhaps non-local drivers, who are less familiar with the Austrian F.G. practice, are more likely to be involved in such accidents, as either first or second vehicle. There was no evidence for that hypothesis. In 50% of rear-end accidents, the first driver was local. This finding suggests that the problems with F.G. are universal and that they are not related to driver understanding of the "true meaning" of F.G. (2). Trucks are underrepresented in the accident population relative to their proportion in traffic.

6.3 Comparison of accidents with traffic characteristics, potential hazards, encounters, and conflicts

Given the limited data collected at one junction, comparisons are qualitative and suggestive only.

The distribution of accidents at the site seems to accurately reflect the movement of traffic through the intersection in terms of direction, driver population, seasonal, daily and hourly variations.

We do not know whether the relative number of accidents (injury and PDO) at the site is larger than at other comparable sites in Austria. Therefore, we can only compare the distribution of the accidents relative to potential hazardous locations and situations as identified through observations at the site.

In Figure 2, we marked the areas in the intersection where:
(a) most of the accidents actually took place;
(b) potential hazards were noted on the basis of a simple engineering analysis and checked through recording of encounters; and
(c) a large number of conflicts were recorded by the various teams.

Figure 2 shows that engineering analysis, traffic behavior observations and conflict analysis identify more hazardous situations than are indicated by the one year accident data. For example, no accidents were recorded in the right-turn lane from Road 308 to Road 145, or in the merging area of Road 145, despite the large number of observed conflicts and encounters. On the other hand, conflict data (as used by us) failed to identify two major sources of accidents - rear-end on Road 146 and right-angle from all directions.

The engineering analysis of the traffic signal program and the supporting analysis of stopping behavior account well for the largest class of accidents, namely rear-end accidents, including the differences in rear-end accidents between the two main approaches.

6.4 Recommendations

The recommendations detailed in this section are based on the observations carried out at the junction, on the analysis of the various measurements, a study of the conflicts observed by the teams and on a study of the accident reports prepared by the Austrians. It seems reasonable to attach greatest significance to those areas of the intersection where the three measures - behavioral, conflicts and accidents complement each other, as described in Figure 2. This occurs in the intersection area proper with left-turning movements. Next areas of priority are those where accident data are in agreement with either of the two other measures - those are the rear-end problems on the two main road approches. The relatively large number of right-angle accidents, many of them with casualties, is in itself reason enough for a search for improvements.

The following recommendations are divided into two main groups. Those specific to the junction and those that require further study and are more methodological.

6.4.1 Recommendations specific to junction improvement.

Signal control

a. The five seconds amber, in addition to the flashing green of three seconds, is considered hazardous. It is suggested to reduce the amber period to 3 seconds and to introduce a 2-second all-red.

b. To consider the elimination of F.G.

c. To install detector loops on the approaches. This will go a long way to remove the problems associated with the rear-end accidents. Loops will also enable a more efficient signal operation.

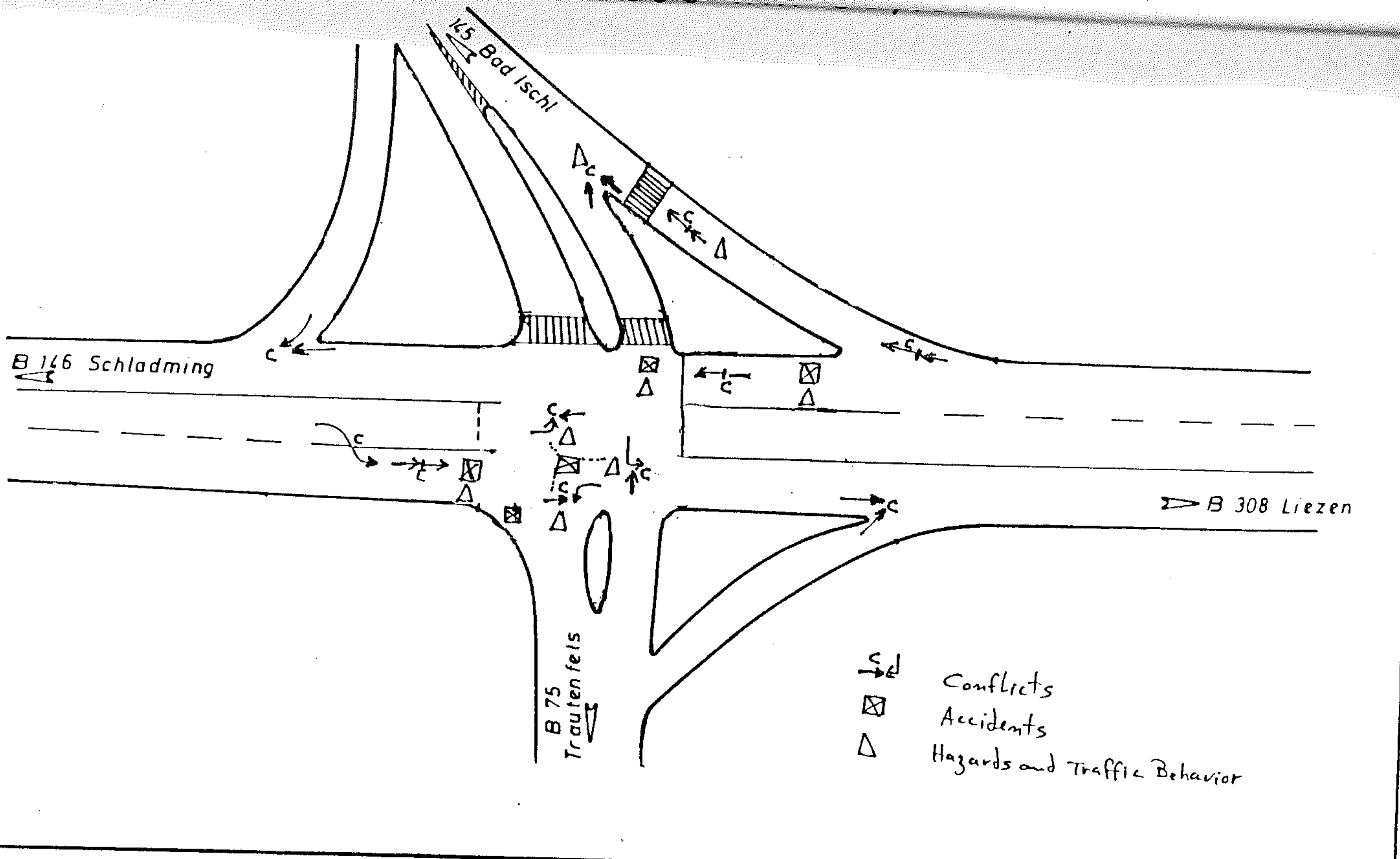

Fig. 2: Problem areas at Trautenfels junction.

Intersection geometry and layout

d. Improve the coherence of the junction layout to reduce left-turn accidents. A major problem is the offset of the two central islands on the M-S roads (Roads 145 and 75). It is possible to rebuild the island on Road 145 by moving it westwards (direction Schladming) - thereby slightly reducing the size of the M-W island. An intermediate solution is to clearly mark and paint the turning paths within the intersection area.

e. A particular problem exists on the eastern approach. Vehicles from direction Liezen come around a curve and frequently find themselves in the left-turn lane. This leads to swerving maneuvers and may lead to conflicts and rear-end accidents. It is suggested to more clearly mark, paint and sign the two lanes and to widen them further from the junction.

f. The advance warnings on the eastern approach are too far away and are lost in the visual distraction of nearby petrol stations. They should be placed closer to the junction, at about 250 m.

g. View obstructions at the merging areas of Roads 146 and 308 should be eliminated. Some trees in the courtyard of the farm - about 170 m east of the junction - should also be removed. In the case of merging right from Road 308 to 145, it would be better to move the merging point further away from the junction by continuing a paint stripe. For right-turning vehicles from Road 75 to Road 308, it would be better to move the merging point further east - but this is difficult because of the gas station entrance.

h. On the western approach - Road 146 from Salzburg - the view of the junction is also obstructed by trees on the right-hand side about 125 m from the junction. The direction sign, placed 240 m from the junction - in the curve - cannot be seen in time and should be moved to 200 m. The advance warning sign, 360 m, is also too far away and could be moved to 200 m.

i. The road surface on all four approaches should be improved to increase its skid resistance. This is especially important on the main road.

6.4.2 Recommendations for further study

a. Repeat the accident analysis with a larger data base and more detailed classification of accidents. Also more representative speed and flow data should be collected at other months of the year to correlate these with the accident data.

b. To measure more accurately the stopping functions and indecision zones on the approaches to the intersection and to redesign, if necessary, the intergreen interval.

c. If elimination of the flashing green is considered unacceptable, it is suggested at least to study its effects in a controlled experiment.

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