

# 13. VIDEO RECORDING OF TRAFFIC ACCIDENTS

Eero PASANEN

Helsinki City Planning Department  
Helsinki, Finland

## ABSTRACT

The video recording of real-life traffic accidents in Helsinki concerns two controlled junctions in the city centre. The actual research material of this study consists of eighteen (18) accidents recorded on video tape. Ten of these are pedestrian accidents and eight are motor vehicle accidents.

Perhaps the most important lesson that can be learned from video-accidents is the central significance of so-called free vehicles. In general, neither pedestrians nor other crossing traffic collide with vehicles in queue.

The special importance of free vehicles is quite decisive when the advantages and disadvantages of speed control in busy city centre traffic are compared. The reduction of the highest speeds effects just those free, most dangerous vehicles, whereas the effects on travel times for the majority in queues are very small.

On the basis of the video-recorded pedestrian accidents, it is estimated that a strict adherence to the new 40 km/h speed limit would reduce the probability of a pedestrian death on Kaivokatu to almost one third. Travel times would be lengthened by only a few percent.

## 13.1 INTRODUCTION

In Finland, traffic safety has been studied much less on urban streets than on rural highways, even though urban traffic is often decisively more dangerous. The number of injurious accidents per driven kilometre on Helsinki's most dangerous business street (Kaivokatu) is about one hundred times higher when compared with the safest motorways (Fig.1).

The reason for inadequate studies in safety in urban traffic is partly due to the administrative division of research resources. However, research in an urban traffic environment is also more complex when compared with the less complicated conditions in rural traffic. In urban conditions, the separation of individual factors from the totality is somewhat difficult.

In this respect, the video recording of accidents is shown to be productive. As far as is known, such a system has not been used before.

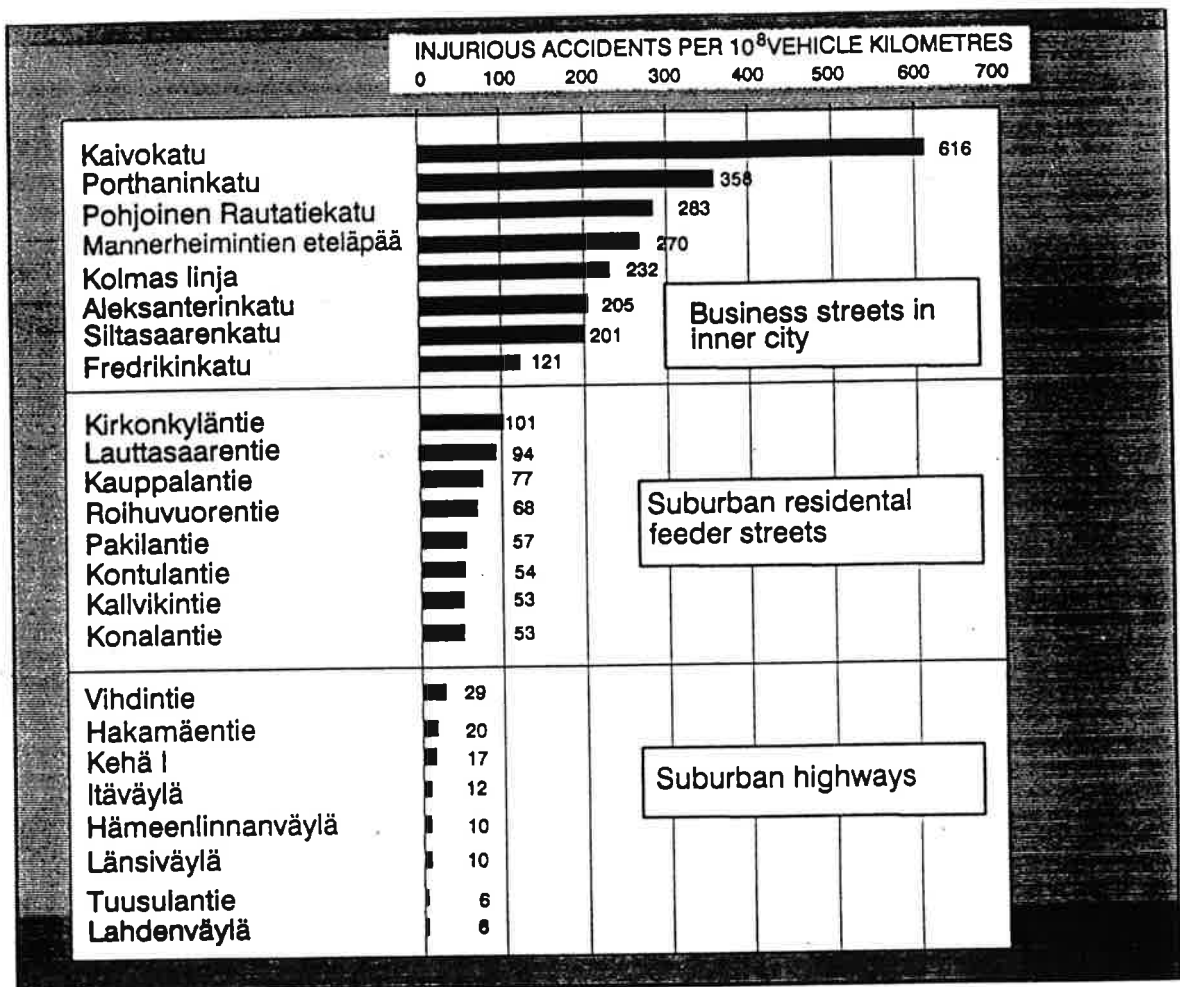


Figure 1: Injurious accidents per driven kilometre for various carriageways in Helsinki.

## 13.2 RESEARCH METHODOLOGY

### 13.2.1 Junctions under study

The video recording concerns two intersections in the centre of Helsinki:

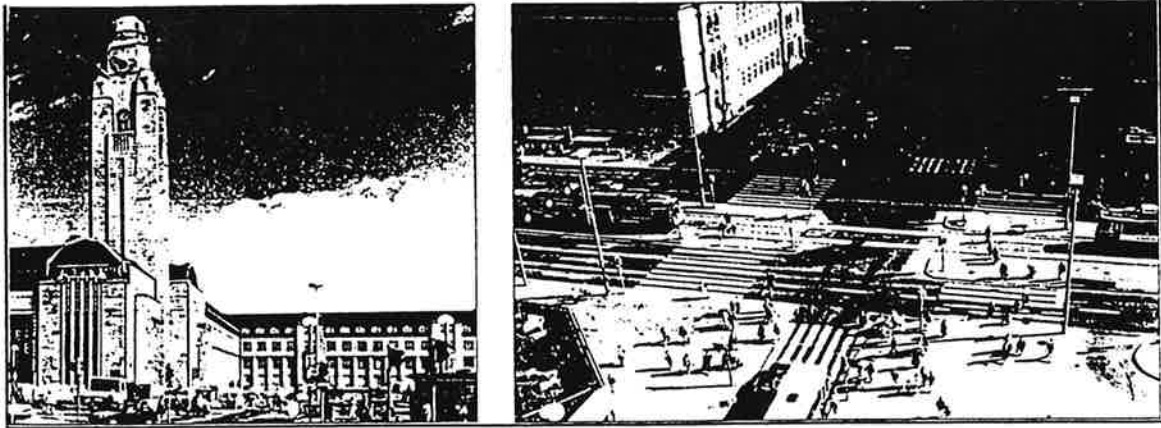
- Kaivokatu/Keskuskatu
- Kaivokatu/Mannerheimintie/Simonkatu

In February 1991, a video camera was installed on the clock tower of Helsinki's central railway station to film traffic at the junction of Kaivokatu and Keskuskatu. The camera is connected to a continuously-running video recorder which automatically rewinds and records on top of the

previous recording. Consequently, a record of events of the last three hours is always available on tape.

The recorder is located in police premises at the central railway station where a 24-hour duty roster is maintained. When the alarm centre is informed of an accident at the junction in question, they contact the railway station police who then retrieve the tape, replace it with a new one, and deliver the accident tape to the Traffic Planning Division.

Figure 2: Camera and field of view on Kaivokatu



Since November 1991, a similar recording system has been operating at the junction of Kaivokatu, Mannerheimintie and Simonkatu. The recorder is located in the control centre of the Helsinki Traffic Authority and the camera on the roof of the building.

Figure 3: Camera and field of view on Mannerheimintie



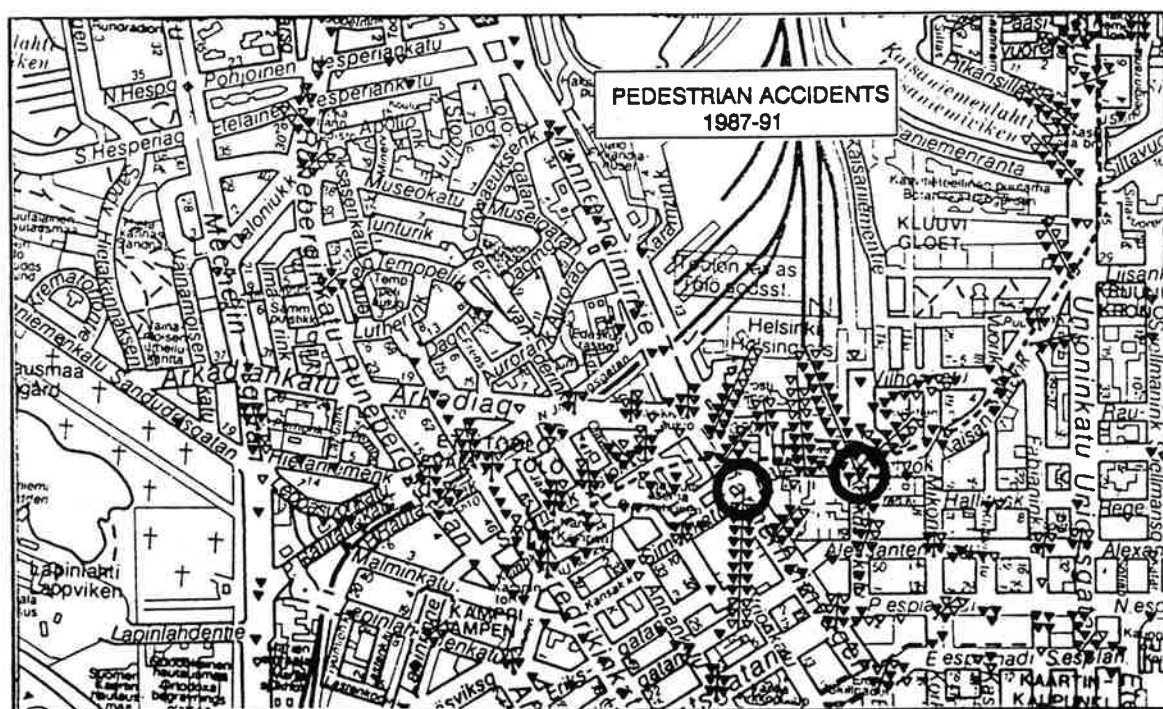
The junctions in question were selected as points of study for two reasons. Firstly, at both points the video recorder can be kept on premises which are close to the camera and which are

manned round-the-clock. In addition, for many years both junctions have been among Helsinki's worst pedestrian accident black spots.

Table 1: Some data for the junctions under study

	Kaivokatu/Keskuskatu	Mannerheimintie/Simonkatu
Traffic volume (veh/day)	32 500	35 000
Share of crossing traffic	16 %	38 %
Speed limit change 1.3.1992	50 - 40 km/h	50 - 40 km/h
Pedestrian crossings (ped/day)	50 000	80 000
Pedestrian accidents 1986-90	29	25
All accidents 1986-90	81	97

Figure 4: Junctions under study



### 13.2.2 Research material

The actual research material of this study consists of eighteen (18) traffic accidents recorded on video tape up to 1.9.1992. Ten of these are pedestrian accidents and eight are motor vehicle accidents.

Of the eighteen accidents under review, 15 occurred at the junction of Kaivokatu/Keskuskatu and 3 at the junction of Kaivokatu/Mannerheimintie/Simonkatu.

According to police reports, 33 accidents and 13 injurious accidents occurred at the junctions in question during the time of recording (see table 2). Consequently, about half of all accidents and close to 80 % of the injurious accidents were captured on videotape.

Some of the unrecorded accidents were reported to the police not until a long time after the actual accident event. Other shortcomings are due to unknown interruptions in information transfer.

Due to the central location of the two junctions under study, the portion of pedestrian accidents that occur at night and which involve the consumption of alcohol is greater in the video-accidents than in the accidents in the whole inner city on average.

Table 2: Accident types in the video-research material and in all police reported accidents (the latter ones in parentheses).

	Injurious accidents	Damage-only accidents	Totals
Pedestrian accidents	10 (12)	- (3)	10 (15)
Rear-end collisions	- (1)	3 (6)	3 (7)
Crossing accidents	- (-)	2 (4)	2 (4)
Other accidents	- (-)	3 (7)	3 (7)
Totals	10 (13)	8 (20)	18 (33)

The course of events of the video-accidents can be followed from the tapes at intervals of 0.02 seconds. Vehicle speeds are measured with the aid of a scale made by computer graphics and copied onto the accident tapes. The records of police interrogations have also been available.

Details of the video-recorded pedestrian accidents are shown in appendices 1-10. Accidents involving motor vehicles only are shown in figure 9.

### **13.2.3 Reference traffic**

One of the strong points in favour of this method of research is the possibility to compare the behaviour of the accident vehicles to the normal traffic flow under the same conditions.

The characteristics of reference traffic are acquired from the video tapes by measuring the speed and the position in the traffic flow of 30 vehicles travelling in the same lane prior to each accident.

## **13.3 RESULTS**

### **13.3.1 Free vehicles**

Traffic flow is considered to be free, if vehicles do not effect each other's driving speed to any noteworthy degree. In this study, a vehicle is defined as free if the time interval to the previous vehicle in the same lane is more than 3 seconds.

As expected, in the three rear-end collisions vehicles in queue were involved. In all other 15 accidents only free vehicles were involved, though only 40 % of the reference traffic consists of free vehicles. This difference between collision vehicles and other traffic is statistically very significant and means that free vehicles mainly determine the safety level of the junctions in question.

Neither pedestrians nor other crossing traffic generally collide with vehicles in queue.

### **13.3.2 Pedestrian accidents**

#### ***Pedestrian behaviour***

All ten video-recorded pedestrian accidents occurred at the zebra crossings of the junctions (see Appendices 1-10). The traffic signals were fully operational in each accident.

In eight cases, the vehicle was driving straight and in two cases the vehicle was turning. In both of the accidents with turning vehicles (see Appendices 8 and 9), a green light showed for both the pedestrians and the vehicles. The vehicles had a duty to give way.

In all eight accidents involving vehicles which were driving straight through, the pedestrian crossed against a red light. In five cases the pedestrian was under the influence of alcohol.

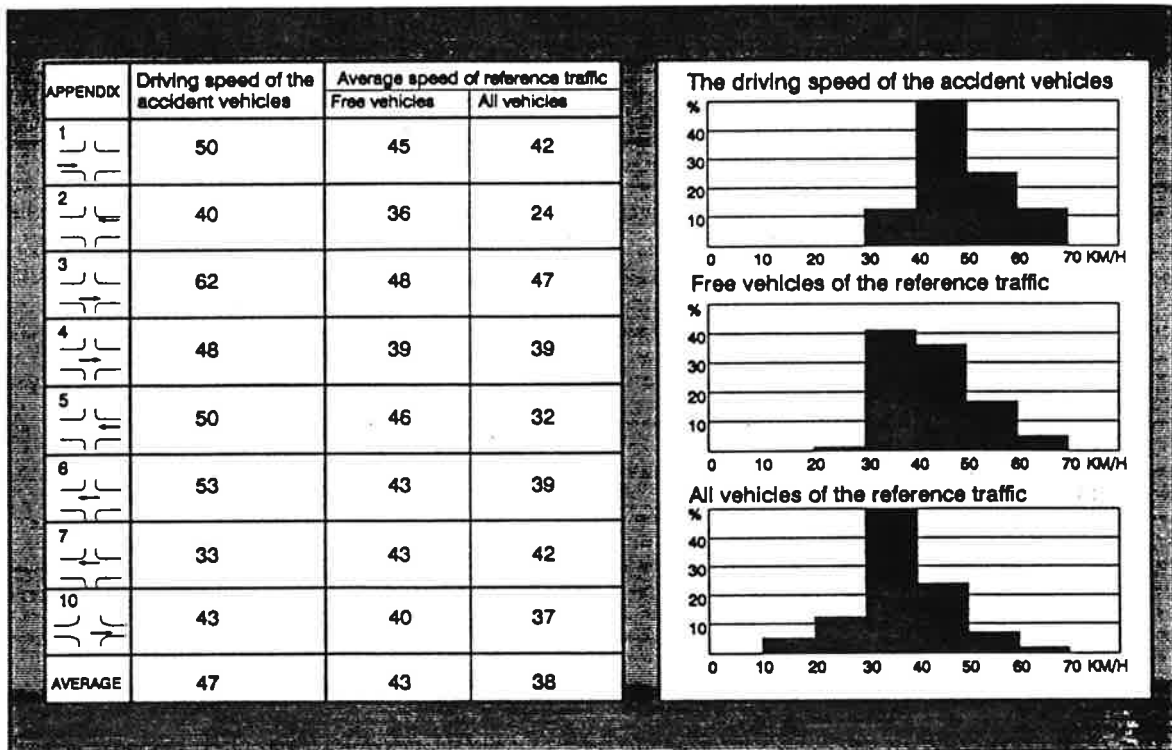
It is not possible to establish, for example, the head movements of the pedestrians on video tape. However, on the basis of the pedestrians' other behaviour and records of police interrogations, it is probable that those pedestrians who walked or ran against a red light made no appraisal whatsoever of approaching traffic. The question was thus not one of conscious risk taking and of failure in estimating one's own actions or the actions of the vehicles.

### 13.3.2 Speeds of collision vehicles

Figure 5 shows the driving speeds (before the accident event) of the eight collision vehicles which drove straight. For reference traffic, the average speed at the point of collision is shown for all vehicles and for free vehicles.

The speed for collision vehicles was on average 47 km/h, i.e. 9 km/h faster than the average speeds for all reference traffic. With the exception of one accident, the speed of the collision vehicles was also higher than the average speed of free vehicles in the reference traffic.

Figure 5: Speeds for accident vehicles (driving straight) and for reference traffic.



If it is desired to estimate the influence of the driving speed on the probability of a pedestrian accident, a comparison between the speed of the collision vehicles and the speeds of all reference traffic is not correct. The accident risk for a vehicle obviously depends more on its position in the traffic flow (free/not free) than on its speed. For that reason, comparisons must be made with free vehicle speeds.

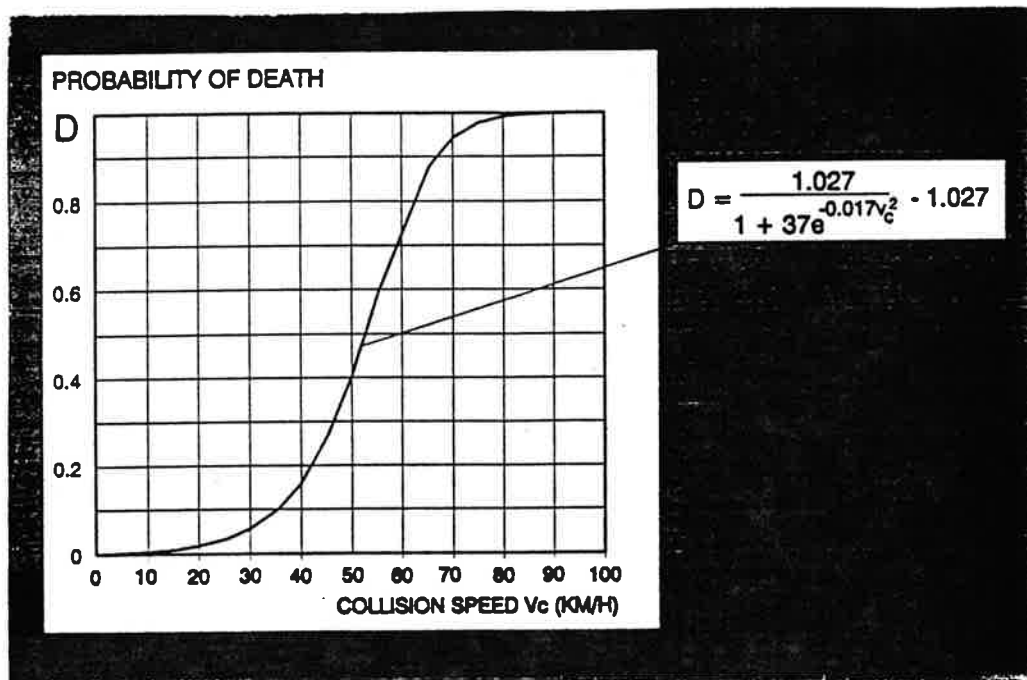
Almost 40 % of the collision vehicles and a good 20 % of the free vehicles in the reference traffic were driving at speeds over 50 km/h. From this it could be calculated that the probability to become involved in a pedestrian accident at a speed over 50 km/h has been more than double when compared with a speed under 50 km/h. It should be noted, however, that for this kind of comparison 8 accidents is statistically a very modest number.

### 13.3.3 The effect of speed changes on safety

For many reasons, an increase in driving speed increases the probability of a pedestrian accident. A much more important safety factor is, however, the influence of driving speed on collision speed and, through it, on the severity of the accident.

The interdependence between the collision speed and the severity of the accident (probability of death) in car/pedestrian accidents is shown in figure 6<sup>1)</sup>.

Figure 6: The influence of the collision speed on the severity of a car/pedestrian accident.



Changes in the probability of death can be thought of as a rough indicator of changes in the overall safety of pedestrians. There are three reasons for this:

- The reduction of fatalities is generally considered to be a fundamental objective of traffic safety work

- The cost of a traffic fatality is estimated to be 50 times higher when compared with the average injury<sup>2)</sup>
- In principle, the changes of collision speed have a similar kind of S-shaped influence on the probability of a severe injury as on the probability of death.

<sup>1)</sup> Pasanen E. 1992 Driving Speeds and Pedestrian Safety A Mathematical Model Helsinki, University of Technology, Transportation Engineering, Publication 77, Otaniemi 1992.

<sup>2)</sup> An estimate of the Finnish Road Administration.

In March 1992 a 40 km/h speed limit was introduced on most of the residential and business streets in the inner city of Helsinki.

Figure 7 shows the measured driving speed and collision speed as well as the corresponding probability of death in each pedestrian video-accident. The table also shows the estimated collision speed and the corresponding probability of death had the driving speed not been higher than 40 km/h. The estimates have been made assuming a driver's brake reaction time of one second (see Appendix 11).

Figure 7: The theoretical effect of a maximum speed of 40 km/h on the video-recorded pedestrian accidents.

APPENDIX	Accident vehicles			Max. speed 40 km/h		
	V	Vc	D	V	Vc	D
1	50	37	0.12	40	10	0.00
2	40	40	0.16	40	40	0.16
3	62	50	0.39	40	0	0.00
4	48	33	0.08	40	14	0.01
5	50	31	0.06	40	0	0.00
6	53	53	0.50	40	40	0.16
7	33	33	0.08	33	33	0.08
8	18	18	0.02	18	18	0.02
9	30	30	0.06	30	30	0.06
10	43	36	0.10	40	29	0.06
AVERAGE PROBABILITY OF DEATH			0.157	→	0.055	

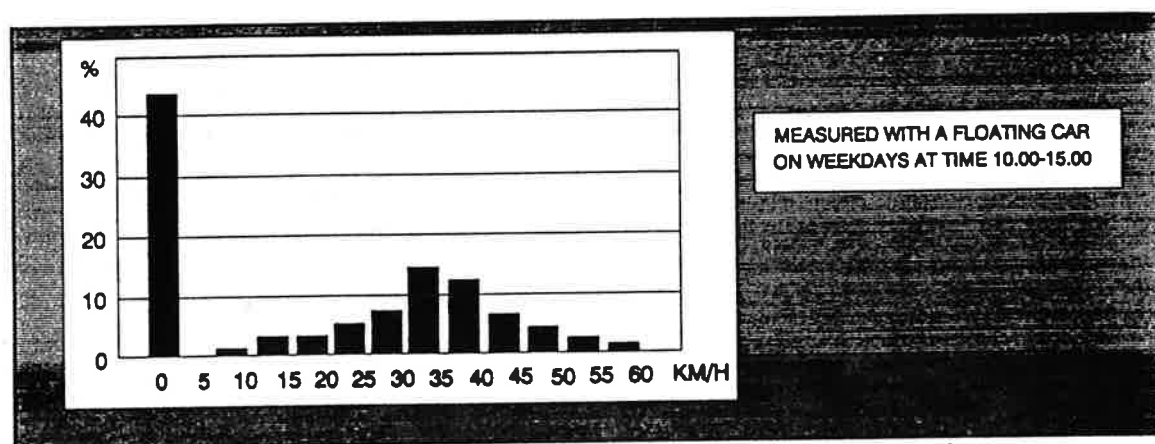
V = DRIVING SPEED  
Vc = COLLISION SPEED  
D = PROBABILITY OF DEATH

Figure 7 shows, that of the ten pedestrian accidents two would have been totally avoided (collision speed=0), if none of the vehicles had been driving faster than 40 km/h. The average probability of death would have been reduced from 0.157 to 0.055, i.e. to almost one third. This evaluation, however, includes the possibility for error influenced by vehicle type and point of collision.

There is one tram and one scooter included among the vehicles in the pedestrian video-accidents. However, figure 6 is based on accidents between cars and pedestrians. Furthermore, in figure 6 the background material comprises only direct front collisions, when the point of collision in the video-accidents was often the vehicle's front corner.

On the basis of the video-recorded accidents, it is estimated that a strict adherence to the new 40 km/h speed limit would reduce the probability of death of a pedestrian on Kaivokatu to almost one third. This estimate includes many factors of uncertainty. It is nevertheless a result worthy of attention, when it has been established that travel times would be lengthened by only a few percent (see Figure 8).

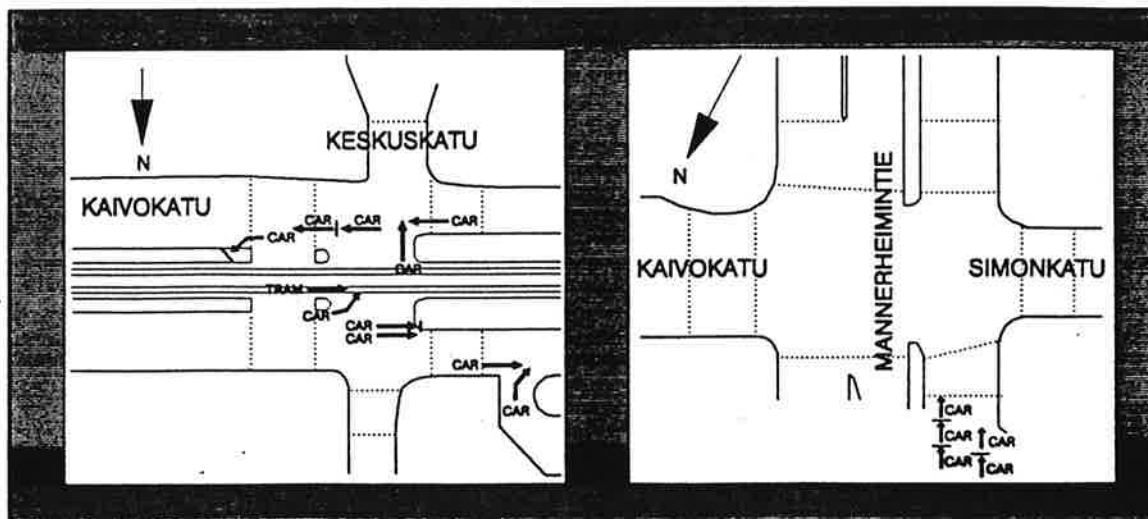
Figure 8: Travel speeds (share of total travel time) on Kaivokatu.



### 13.3.3 Accidents between motor vehicles

Figure 9 shows video-accidents between motor vehicles. Because of the diversity of accident types and the poor sampling fraction of these accidents (see Table 2), no specific analyses are made. However, it can be mentioned that, with the exception of rear-end collisions, in all the other accidents only so-called free vehicles were involved.

Figure 9: Video-recorded motor vehicle accidents at the junctions of Kaivokatu/Keskuskatu (6 accidents) and Kaivokatu/Mannerheimintie/Simonkatu (2 accidents).



## 13.4 CONCLUSIONS

### 13.4.1 Free vehicles, a decisive safety factor in city centre traffic

Perhaps the most important lesson that can be learned from video-recorded accidents is the central significance of the so-called free vehicles, i.e. vehicles not in queue. In general, neither pedestrians nor other crossing traffic collide with vehicles in queue. This is in itself natural, since a continuous flow of traffic in the field of vision is undoubtedly a more efficient warning signal than any sign or regulation. However, the significance of free vehicles is not apparent from conventional accident reports of police or of investigative teams.

When the influence of various factors on traffic safety is studied, the number of accidents is traditionally compared to the vehicle mileage. Results have often been unclear and even conflicting. One reason for this may be that the traffic volume and the number of free vehicles are different things.

For example, if we were to study the influence of darkness on the risk of accidents, we could easily go astray if we did not bear in mind that at night the share of free vehicles is usually much greater than during the day.

The special importance of free vehicles is quite decisive when the advantages and disadvantages of speed control in busy city centre traffic are compared. The reduction of highest speeds effects just those free, most dangerous vehicles, whereas the effects on travel times for the majority in queues is rather small.

### **13.4.2 Pedestrian behaviour**

In pedestrian accidents, a pedestrian rarely tries to cross a street consciously between a short gap and fails through the miscalculation of his own or some other person's performance.

Pedestrians who cross a street are, for various reasons, sometimes momentarily in such a state or situation where they do not think at all of approaching vehicles. An accident occurs if the vehicle happens to be on the 'right' spot, travelling at the 'right' speed.

This offers a pessimistic outlook on the possibility to reduce pedestrian accidents by improving pedestrian behaviour. If even the threat of loss of life does not prevent the pedestrian from behaving quite thoughtlessly, how can education or the threat of a fine become a more effective deterrent?

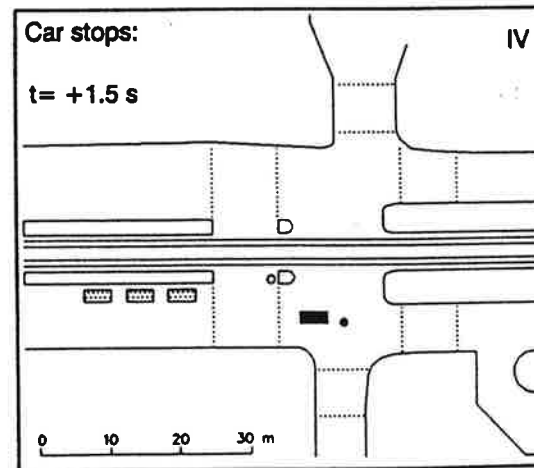
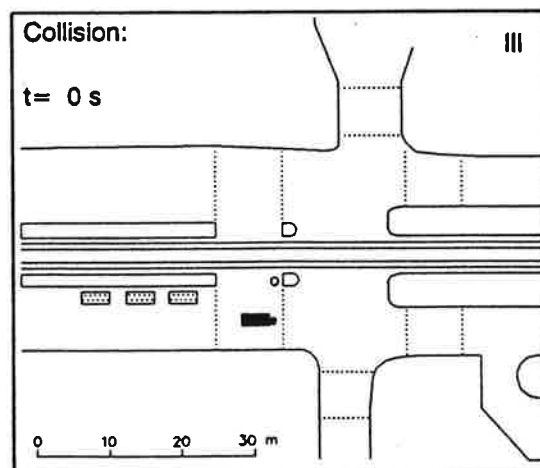
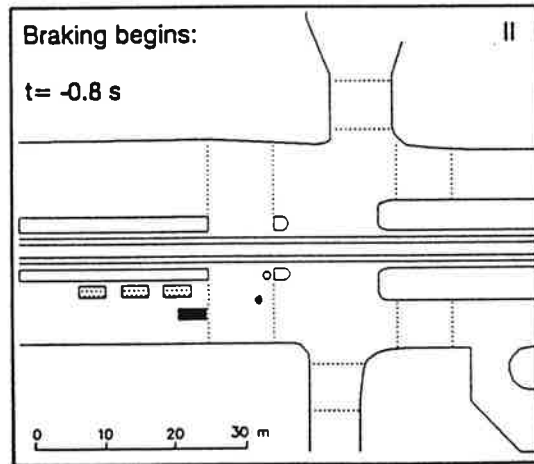
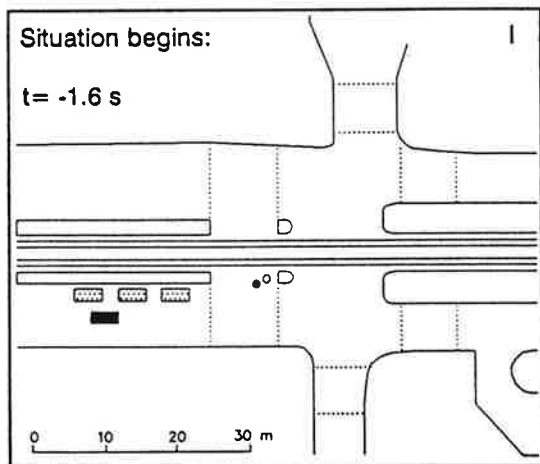
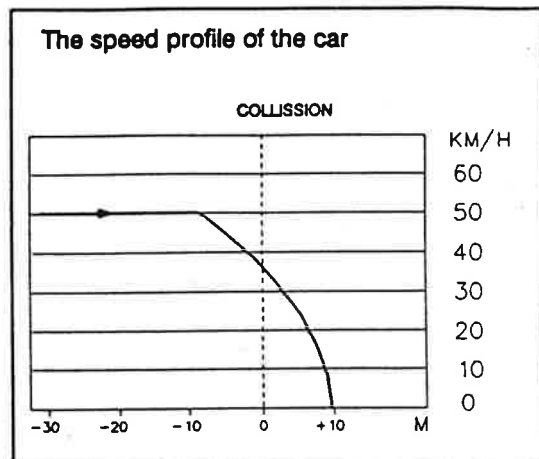
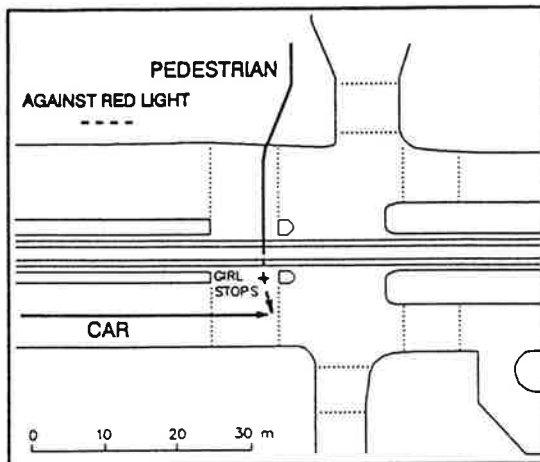
### **13.4.3 Speed kills**

On the basis of the video-recorded accidents, it is estimated that a strict adherence to the new 40 km/h speed limit would reduce the probability of death of a pedestrian on Kaivokatu to almost one third. This estimate includes many factors of uncertainty. It is nevertheless a result worthy of attention, when it has been established that travel times would be lengthened by only a few percent.

## Appendix 1

PEDESTRIAN CAR Wednesday 13.2.1991 at time 14.13

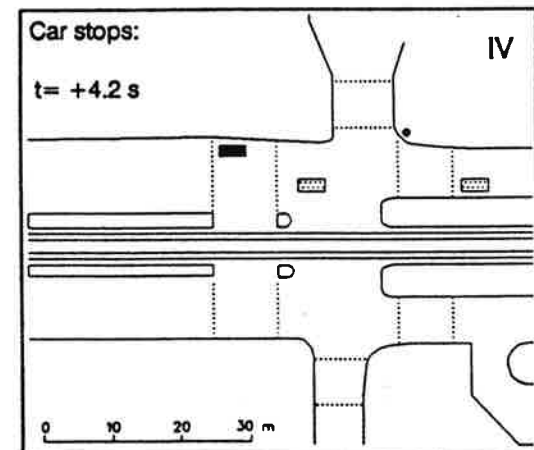
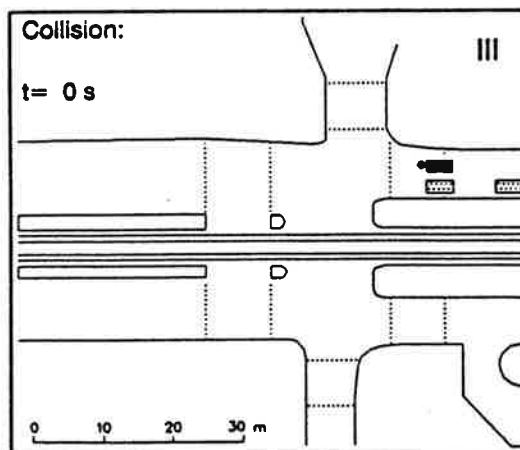
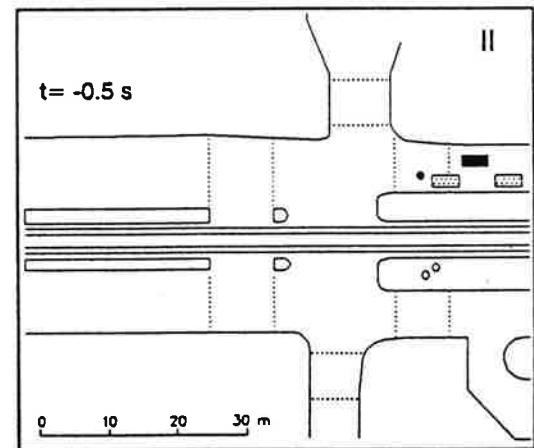
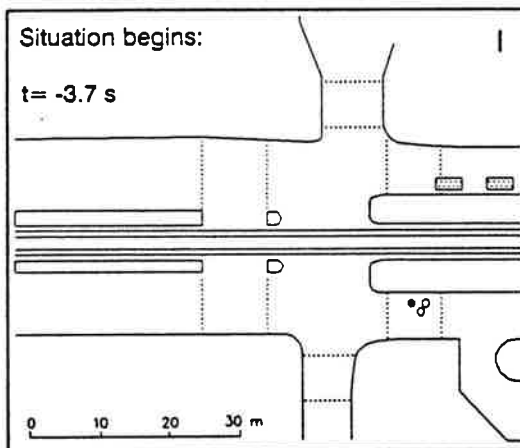
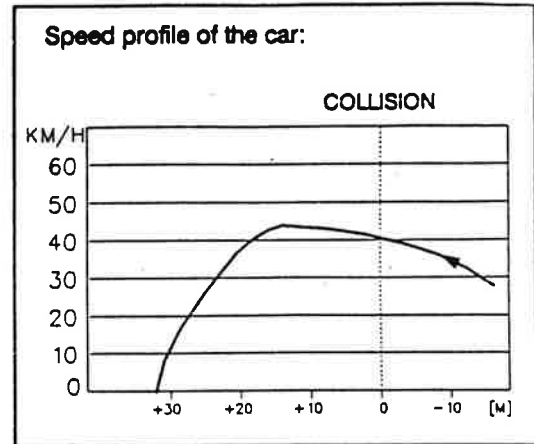
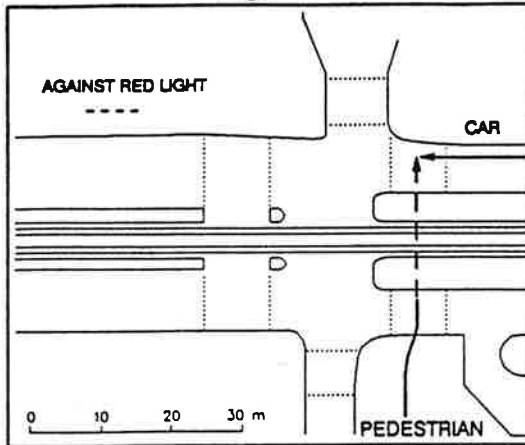
Two 14-year-old girls crossed the Kaivokatu pedestrian crossing and stopped at the central reserve when the pedestrian signal turned to red. Suddenly, one of the girls ran across the street against the red signal. A car proceeding along Kaivokatu just managed to begin to brake but collided with the girl, who then struck the bonnet and windscreen and was knocked forward ahead of the car. The girl suffered only minor physical injuries.



## Appendix 2

PEDESTRIAN CAR Tuesday 12.3.1991 at time 00.12

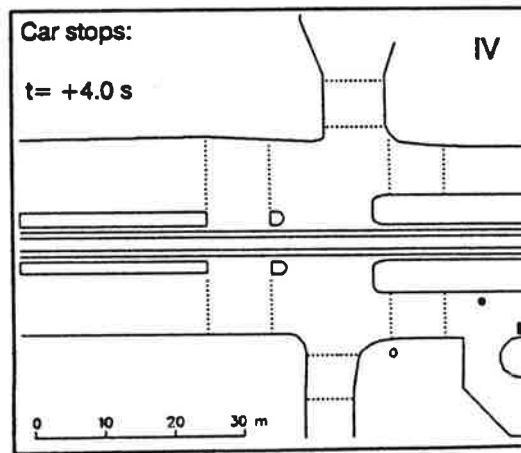
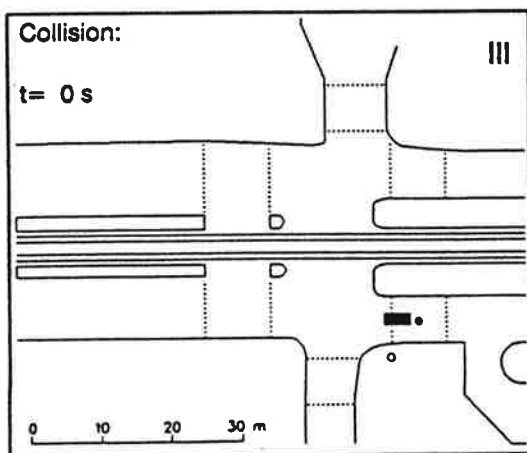
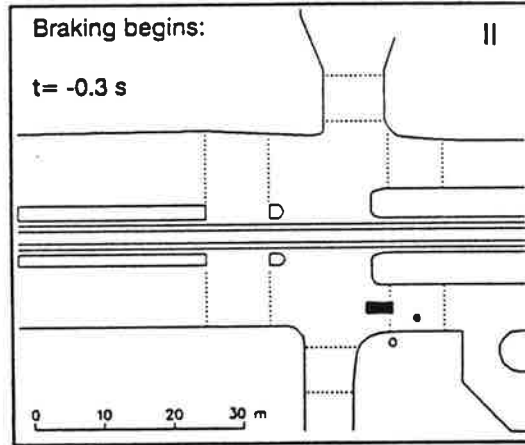
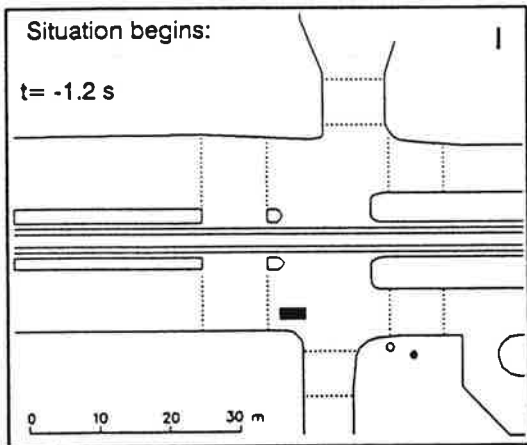
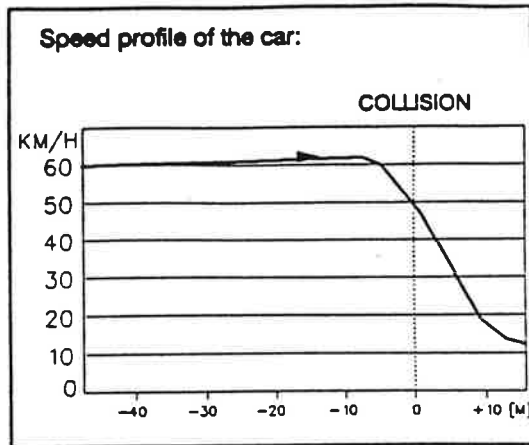
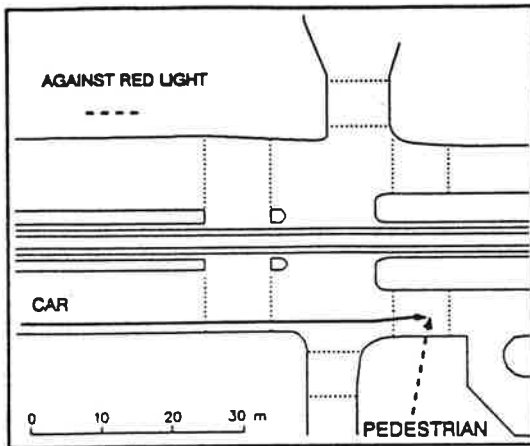
A young man with his friends was crossing the first carriageway of Kaivokatu on the way from one restaurant to another. When the pedestrian signal changed to red, he began to run to get across the second carriageway before a stationary car starts off. A cab in the adjacent lane came from beyond the stationary car and collided with the pedestrian who was thrown via the cab's right front corner onto the sidewalk. The pedestrian fractured his hand and suffered slight bruises to his face and legs.



## Appendix 3

PEDESTRIAN/CAR Wednesday 17.4.1991 at time 00.17

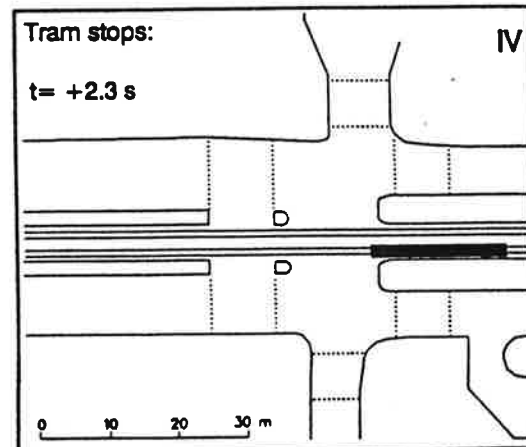
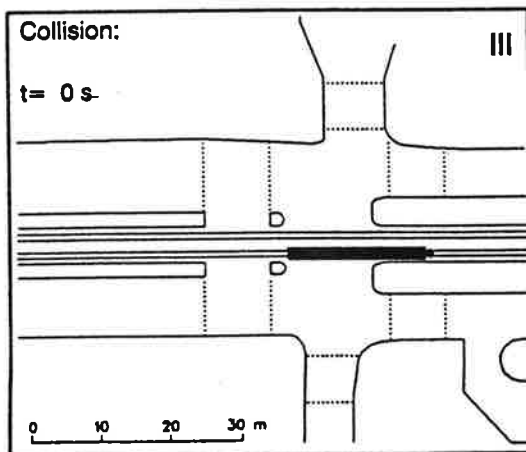
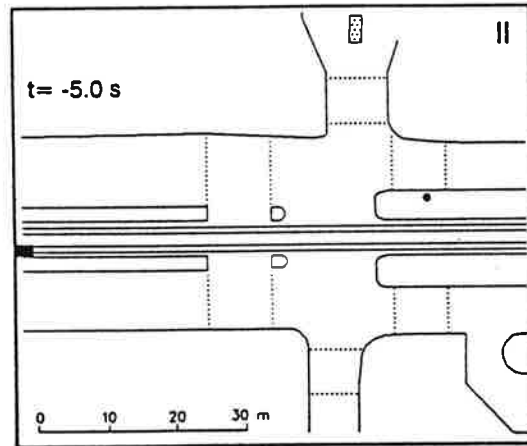
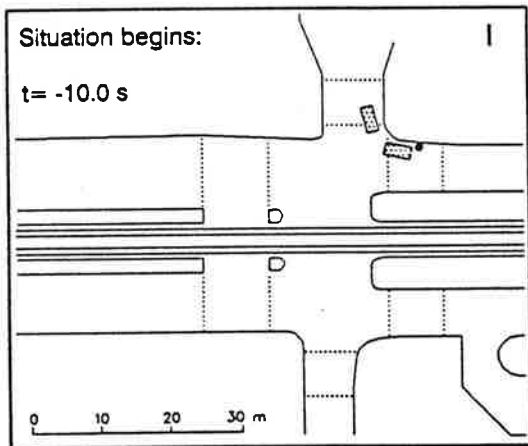
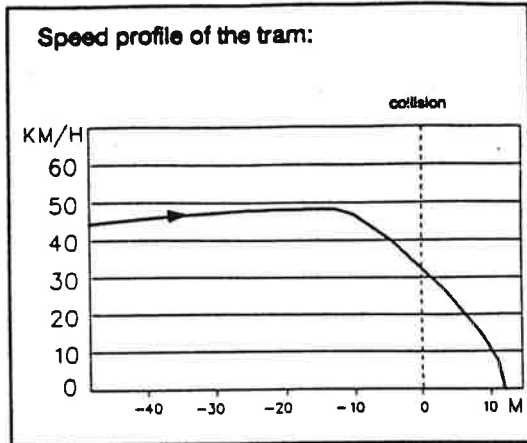
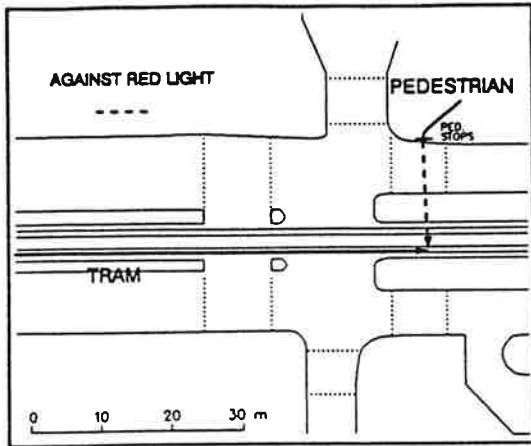
A 15-year-old girl runs after her friends, who are waiting at the Kaivokatu tram stop. A few meters before the zebra crossing she accelerates and runs against a red signal into the path of a cab approaching from the left. The girl was under the influence of alcohol. The driver tried to swerve to the left and managed to begin to brake just before colliding. The cab's windscreen was broken in the collision but the girl survived with slight injuries.



## Appendix 4

PEDESTRIAN/TRAM Wednesday 26.5.1991 at time 00.28

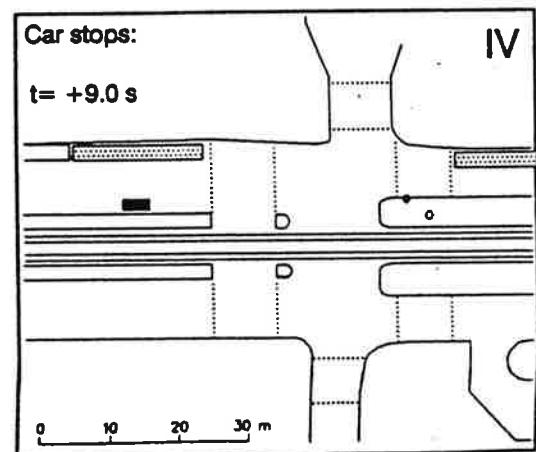
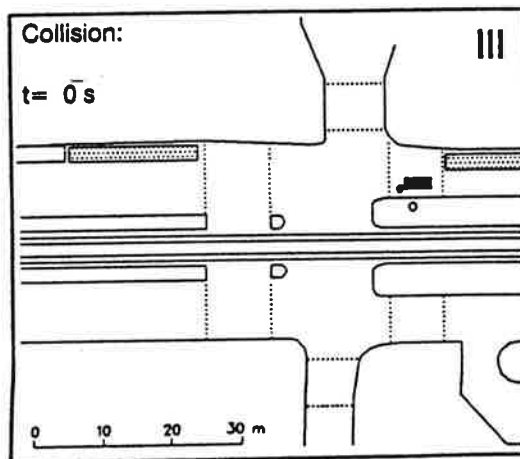
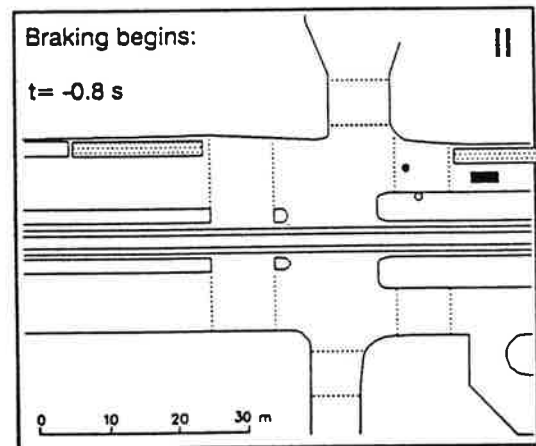
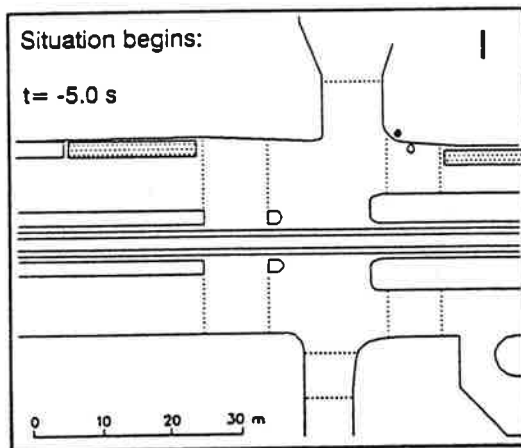
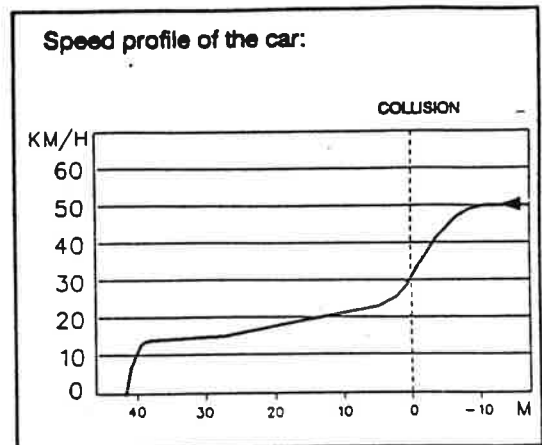
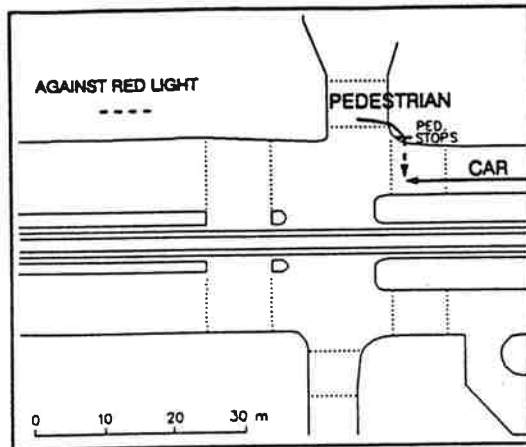
A young man begins to cross Kaivokatu against the red signal. He walks steadily across the carriageway and straight on in front of a tram. He suffers fatal head injuries after striking the front of the tram. The driver gives a warning signal before he starts to brake.



## Appendix 5

PEDESTRIAN/CAR Saturday 1.6.1991 at time 12.31

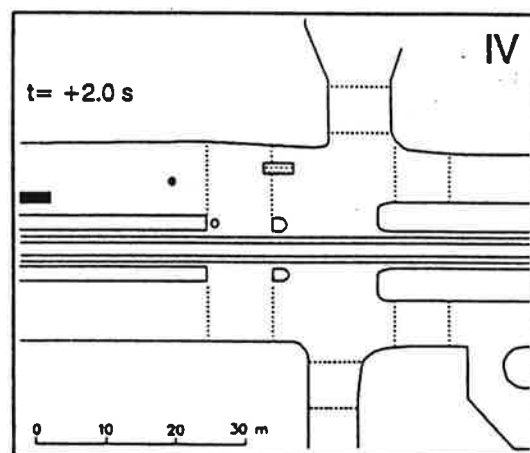
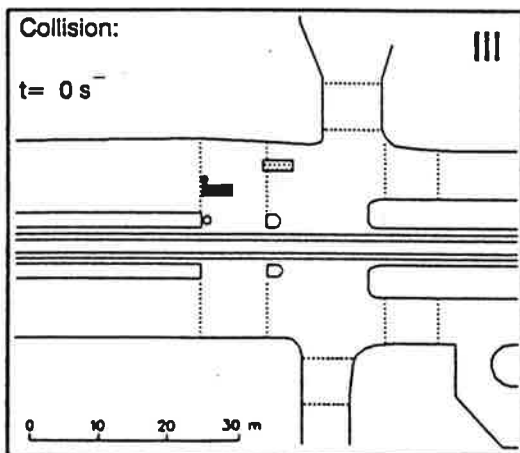
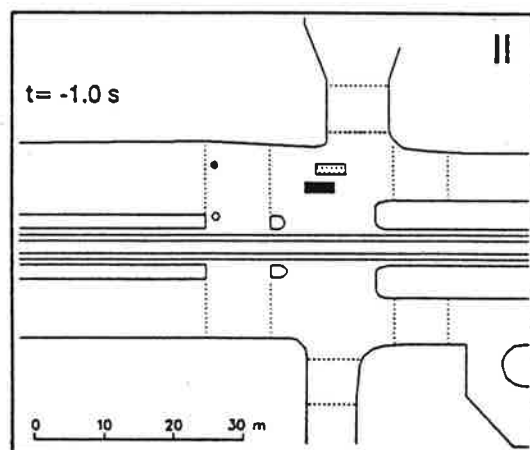
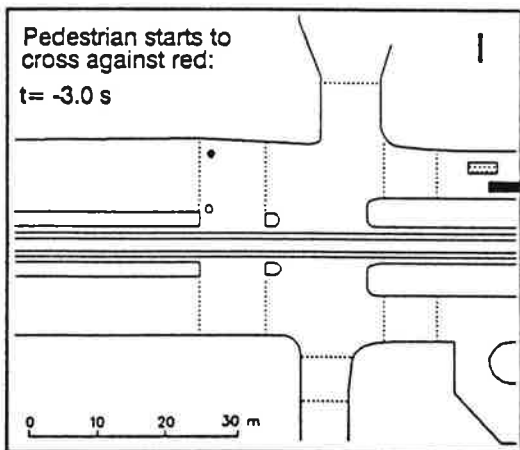
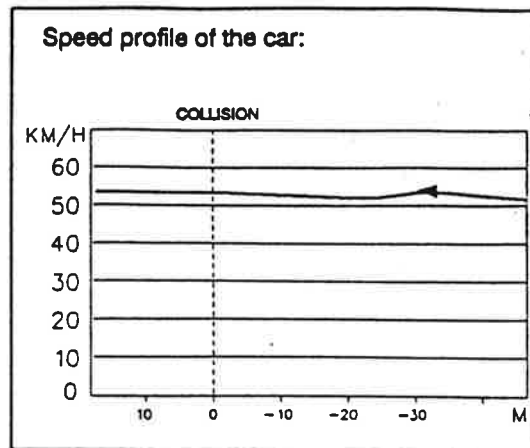
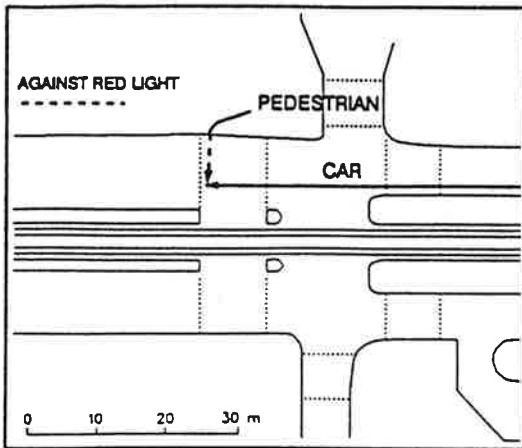
An articulated bus stopped at the crossing on a green signal phase so as not to block the junction beyond the crossing. A middle-aged pedestrian proceeded to cross against the red light followed by a 75-year-old lady who had been waiting for a green signal. The Lady did not notice the car approaching from behind the bus. The car driver tried to swerve to the right. The left corner of the car struck the pedestrian, who suffered fractures to her wrist and ribs.



## Appendix 6

PEDESTRIAN/CAR Thursday 27.2.1992 at time 00.38

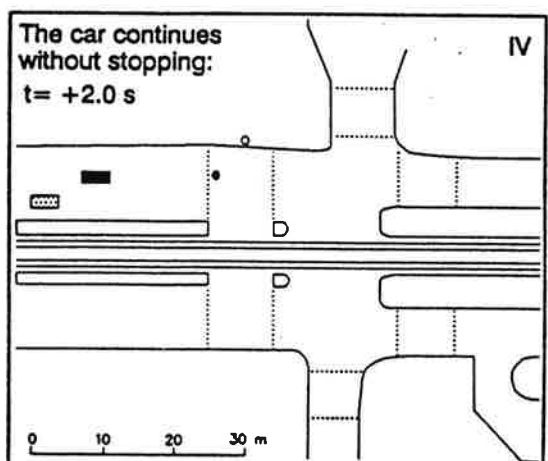
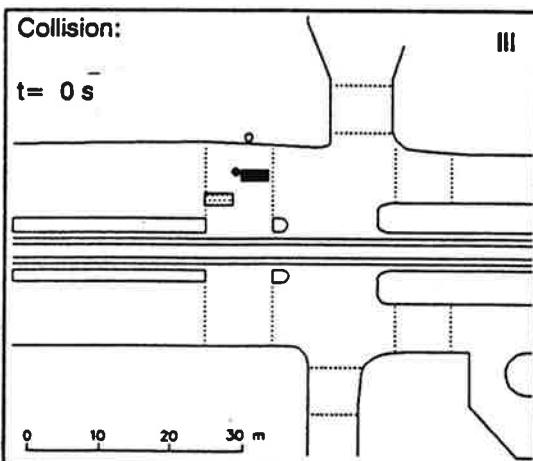
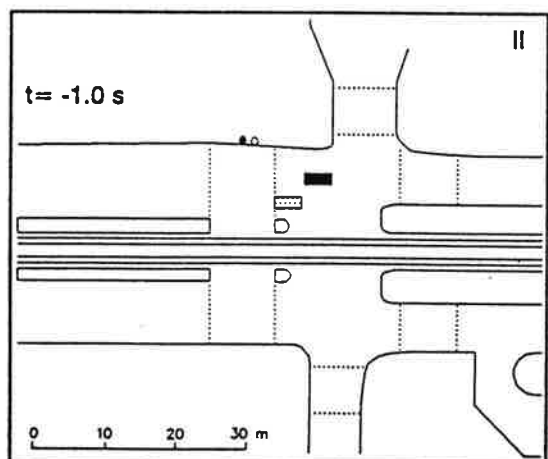
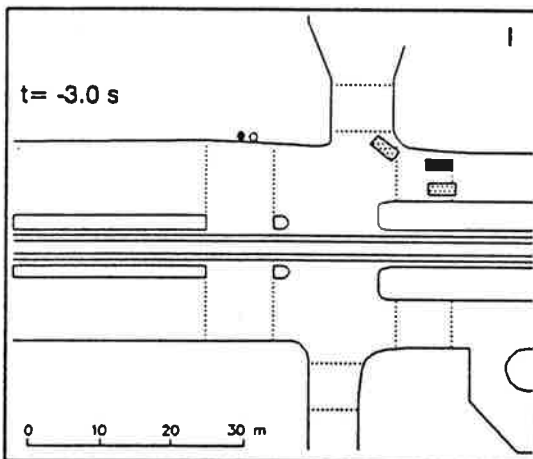
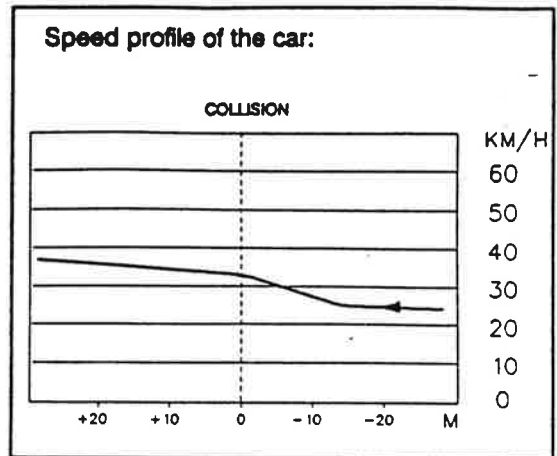
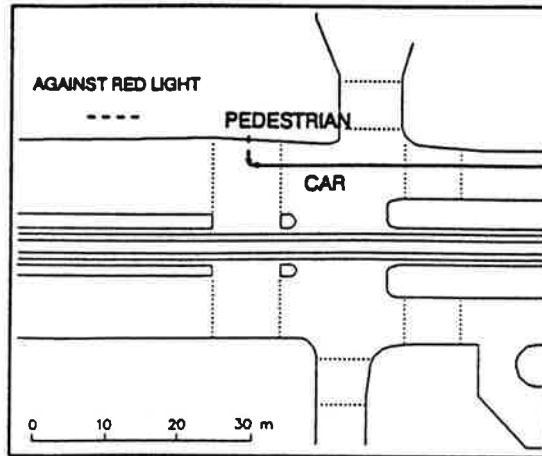
A 33-year-old pedestrian followed his girlfriend and was crossing Kaivokatu against a red light. At the mid-point of the crossing he began to run and collided with the front bumper of an approaching car. The driver did not immediately react to the collision. The pedestrian suffered a serious leg fracture with mild bruises to the shoulder and head. The pedestrian was under the influence of alcohol.



## Appendix 7

PEDESTRIAN/CAR Friday 24.7.1992 at time 01.42

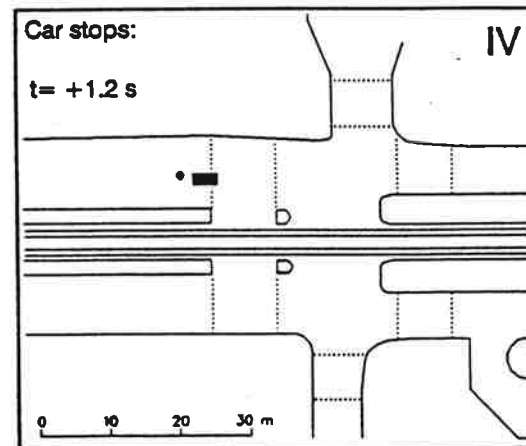
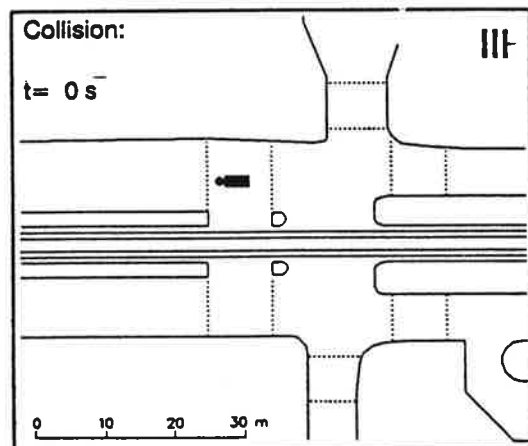
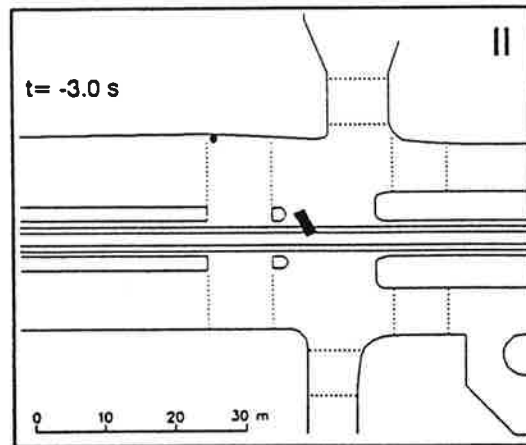
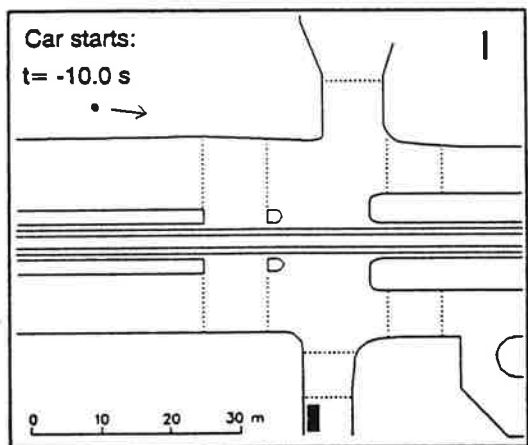
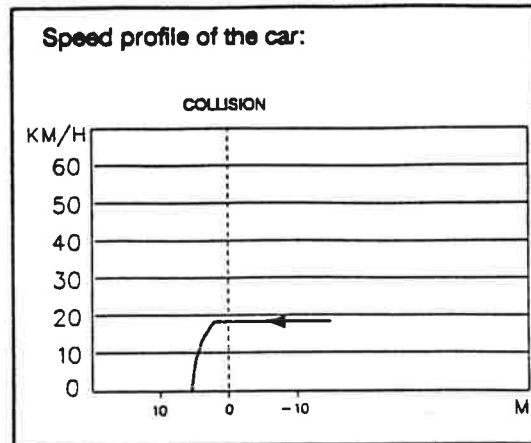
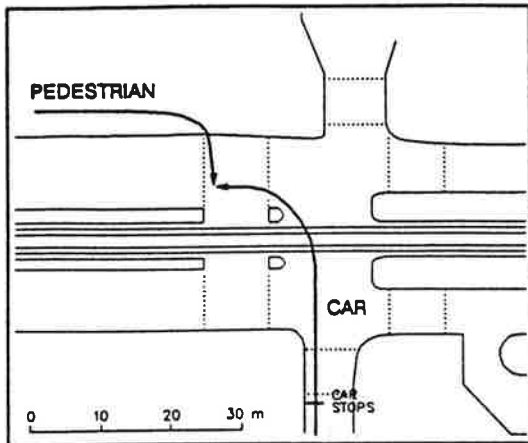
A 25-year-old pedestrian, who is under the influence of alcohol, is standing on the sidewalk but suddenly runs against a red light in front of an approaching car. In the collision he loses consciousness and suffers a slight concussion of the brain. The collision car proceeded without stopping.



## Appendix 8

PEDESTRIAN/CAR Monday 5.8.1991 at time 11.48

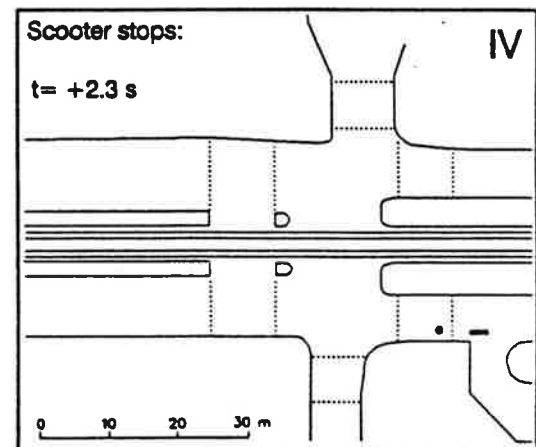
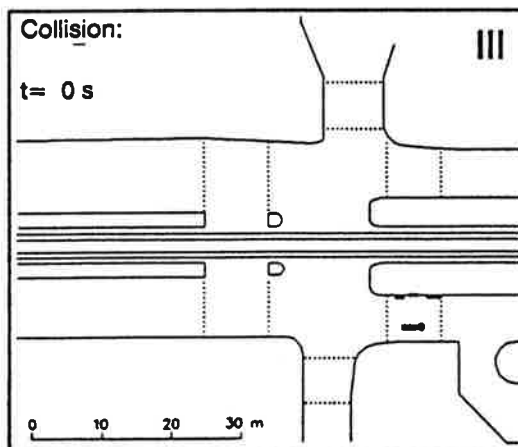
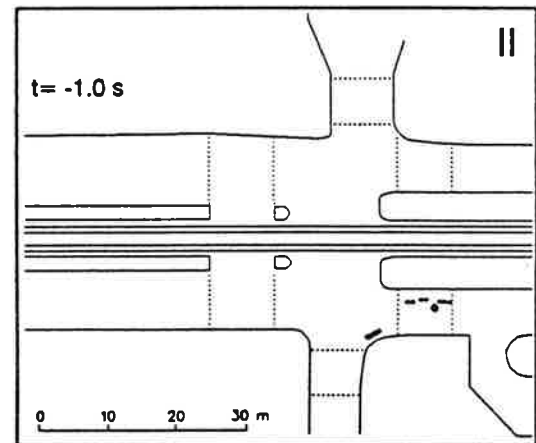
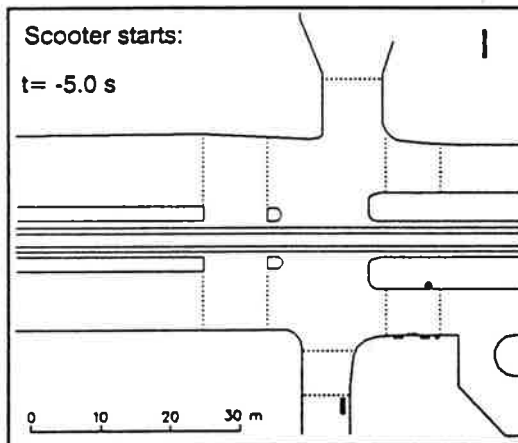
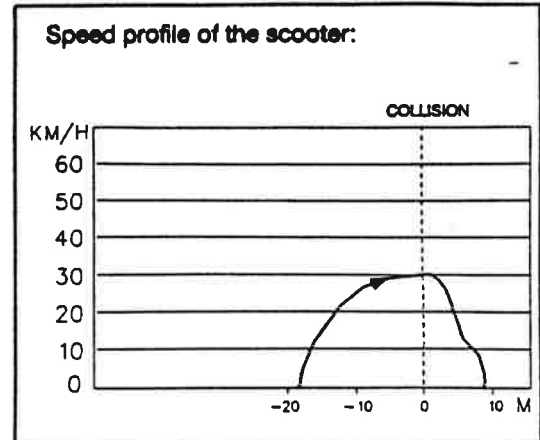
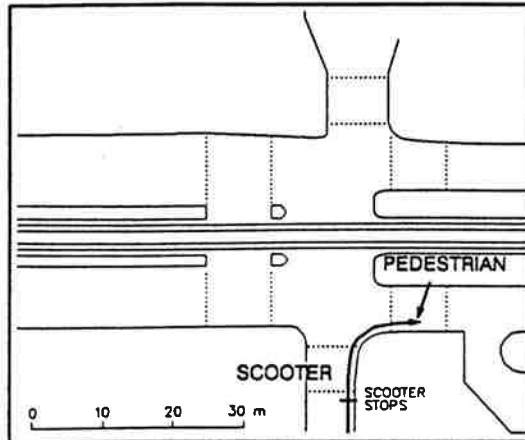
A cab proceeded to turn left from Keskuskatu to Kaivokatu. At the same time a pedestrian was crossing the Kaivokatu pedestrian crossing with the green light. For some reason the cab driver did not react to the pedestrian before the collision. The pedestrian was thrown forward onto the street via the car's bonnet and windscreen.



## Appendix 9

PEDESTRIAN/MOTOR SCOOTER Saturday 23.5.1992 at time 00.09

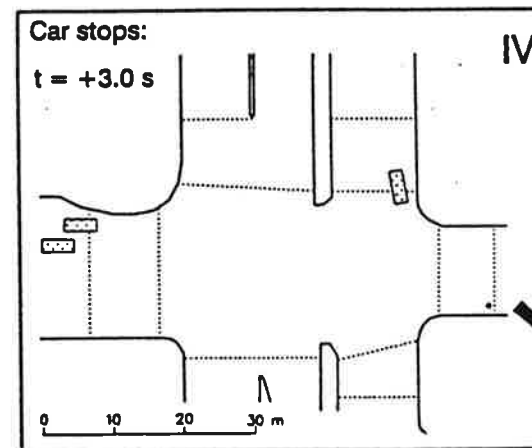
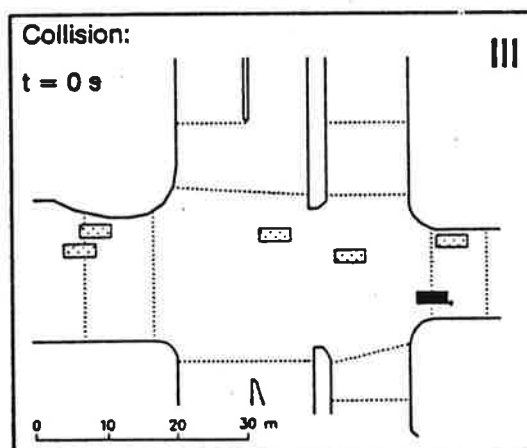
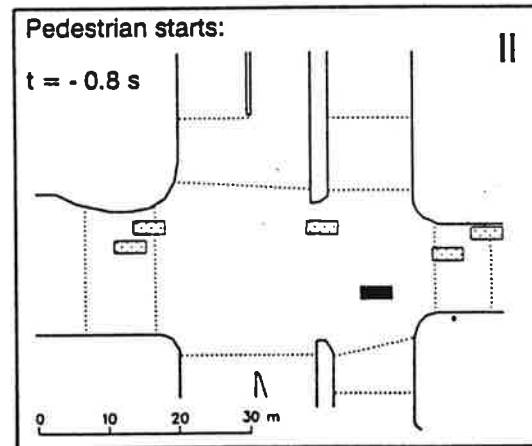
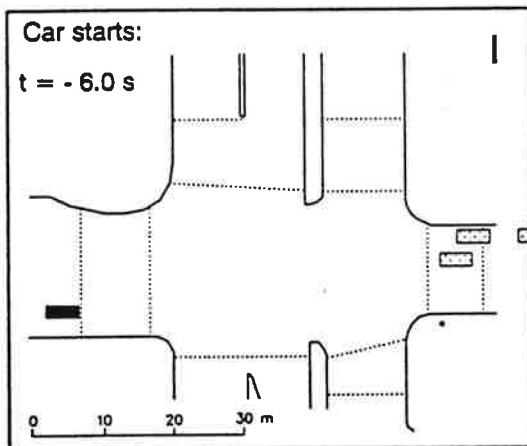
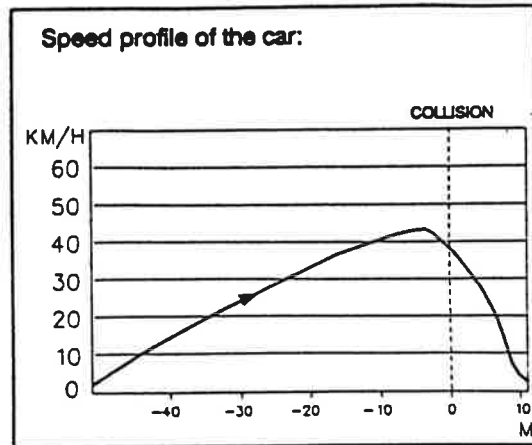
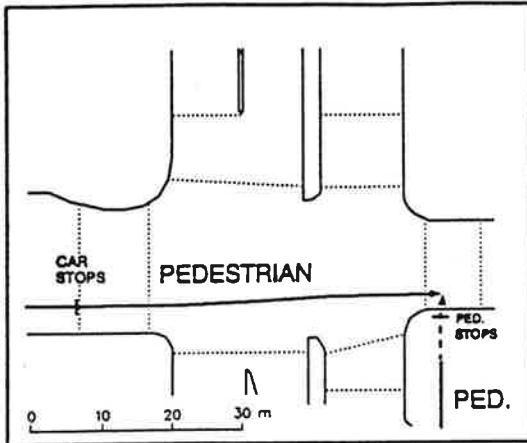
When the traffic lights changed to green, a scooter proceeded from Keskuskatu to turn right onto Kaivokatu. At the same time, several pedestrians proceeded to cross Kaivokatu with the green light in the direction of the railway station. The driver did not notice a crossing pedestrian from the opposite direction in time. The pedestrian collided with the scooter's windshield and suffered torn ligaments in her knee. The driver and the pedestrian had consumed some alcohol.



## Appendix 10

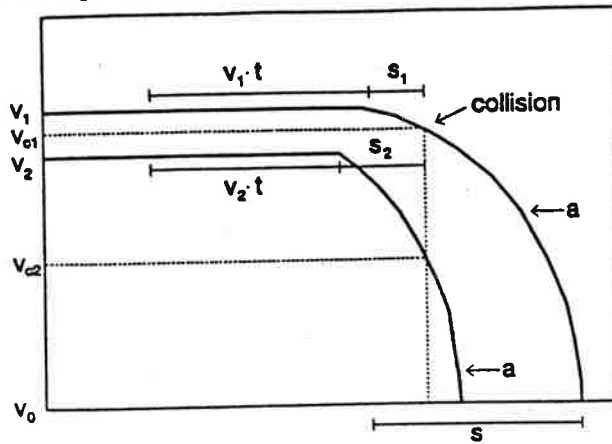
PEDESTRIAN/CAR Friday 13.12.1991 at time 23.21

An 18-year-old man was walking on the Mannerheimintie sidewalk towards the Simonkatu crossing where he stopped at the red light. When the traffic flow from the right ended, he suddenly ran across the street and was struck by a cab, which came from the left.



## Appendix 11

The collision speed and the probability of death if the max. driving speed would have been 40km/h in the pedestrian video-accidents..



- $v_1$  = driving speed (m/s)
- $v_{c1}$  = collision speed (m/s)
- $v_2 = 40 \text{ km/h} = 11.1 \text{ m/s}$
- $v_{c2}$  = collision speed, if max. driving speed is 40 km/h
- $a$  = vehicle deceleration when braking ( $\text{m/s}^2$ )
- $s$  = braking distance (m)
- $t$  = reaction time of the driver (1 s)

$V_1, V_0, S$  and  $S_1$  are measured from video-tapes.

$$a = (v_1^2 - v_0^2) / (2s) \quad s_2 = s_1 + (v_1 - v_2)t \quad v_{c2} = \sqrt{v_2^2 - 2as_2}$$

$$D_2 = \frac{1.027}{1 + 37e^{-0.017v_{c2}^2}} - 1.027$$

	Accident vehicles							If max speed 40 km/h		
	$V_1$	$V_0$	$S$	$S_1$	$a$	$V_{c1}$	$D_1$	$V_2$	$V_{c2}$	$D_2$
APP 1	50	0	18	8	5.4	37	0.12	40	10	0.00
APP 2	40	-	-	-	-	40	0.16	40	40	0.16
APP 3	62	30	14	6.5	8.1	50	0.39	40	0	0
APP 4	48	0	25	13	3.6	33	0.08	40	14	0.01
APP 5	50	25	12	10	6.0	31	0.06	40	0	0
APP 6	53	-	-	-	-	53	0.50	40	40	0.16
APP 7	36	-	-	-	-	36	0.10	36	36	0.10
APP 8	18	-	-	-	-	18	0.02	18	18	0.02
APP 9	30	-	-	-	-	30	0.06	30	30	0.06
APP 10	43	20	10	4	5.6	36	0.10	40	29	0.06

$V$  = DRIVING SPEED (KM/H)  
 $V_c$  = COLLISION SPEED (KM/H)  
 $D$  = PROBABILITY OF DEATH