# AN APPROACH TO AN INJURY-MINIMIZING TRAVEL DISTRIBUTION BY MEANS OF TRANSPORTATION

Åke FORSSTRÖM
E. professor of Human Geography
School of Economics and Commercial Law, University of Göteborg
Göteborg - Sweden

## INTRODUCTION

The total safety of person transport systems in urban regions of an industrialized country has been simulated by a model. The likely development of casualties and losses during person transports has been produced when the distribution of road-users changed between cars and public means of transportation (PMT).

## 1. PROBLEM

There is an agreement in international scientific journals in general and in public opinion in Sweden in particular, that traffic safety is increased if road-users would use public means of transportation more extensively. However, this opinion is questioned in this paper.

### 1.1 Arguments for a new approach

Debates concerning the societal costs of traffic safety are based on casualties and losses in road traffic accidents (RTA). There are two aspects to consider. First, the casualties in RTAs are heavily underestimated. From one half up to two thirds of all casualties are not accounted for. Second, the RTA concept is defined as events involving a moving vehicle. Track vehicles are not defined as a vehicle. So, traffic safety discussions are subject to two major deficiencies, a poor statistical reliability and a pursed validity, which calls for a new approach.

#### 1.1.1. Transportgeographic arguments

Considering the geographic dimension of a transport system and a traffic system respectively, it is quite obvious that transport and traffic movements are not similar. The traffic movement is concerned with the path of a particular vehicle, while the transport movement is attached to the path of a transfered person or an entity of goods. Thus, the conventional analysis of road system safety highlights the view of the road authority, which primary responsibility is the safety of roads and secondary the safety of a travelling person irrespective of transport system.

Obviously, the accidents of the road traffic system is only one smaller set of all accidents of the societal transport system.

#### 1.1.2. Economic arguments

From an economic point of view costs are related either to firm or to society. The value of road traffic accident and track vehicle accident losses are firm-related cost concepts. One cannot evaluate societal costs with a firm-related cost concept alone.

It is somewhat embarrasing to have to point out that buses ought to be analysed as a subsystem and that the systems of track vehicles and unprotected road-users also should be taken into account.The traffic accident concept has to be replaced due to arguments in welfare economics.

1.1.3. In search for a new conception

The traffic accident concept is inadequate in this context. It has to be supplemented in a number of ways. There is a need for an approach, which facilitates the different cases of interferences in a complex superior transport system of an metropolitan region. In view of this approach new concepts have to be developed, which could be the foundations of a new theory of transportation safety.

## 2. THE TRANSPORT APPROACH

My theoretical approach have its roots in time geography and systems theory . The casualties of each transport system is apprehanded from a societal cost perspective. The theoretical concepts are not derived from a traffic system point of view, but rather based on a conception of transport systems functioning.

### 2.1 Aspects of time geography

The concept of the individual path, from time geography, is applied in this paper. The travel chain concept is a part of this path. It allows for the use of several transport subsystems. In general a transport subsystem consists of one dominant way of travelling and feeder transports. There are generally only five transport moments in a subsystem: walking, embarking, travelling by vehicle, debarking and walking. In principle a total account of injuries and losses due to all kinds of accidents during a journey is desirable.

The transport moments of a journey are replaceable, but they cannot be eliminated. So from the passenger and the road user point of view, every risk of transport moment accident must be considered. The total safety of the transport situation in a region must include the safety of all subsystems in that region.

Traffic safety has a limiting definition. The word traffic has an misleading effect in itself. The intermingling of vehicles driving back and forth guides one to the supposed importance of interferences. Some of these develop to vehicle interactions leading to accidents. This way of thinking is being verified by the observations of dramatic collisions with personal injury. It has been formalized in the generally accepted definition of road traffic accidents, which is in fact addressed to fit the danger of using motor cars. A safety conception based the meaning of transport would help to eliminate this bias. Thus, the conventional safety conception cannot be taken for granted.

### 2.2 An extended safety conception

2.2.1 New safety concepts

The traffic safety concept is biased. It excludes track vehicle accidents and walking accidents to and from and on terminals. A transport approach is the starting point when formulating a new conception.

Changing the basic object in traffic accident research from the accident or the incident itself to the journey viewed as a chain of transport moments gives way for new concepts. The old traffic safety concept defined by road traffic accidents is supplemented by the wider concept of **travel safety** which refers to the chain of transport moments. It applies to any accident at any of the transport moments. Road traffic accidents are thus an important subset to travel accidents. Track vehicle accidents are obvious travel safety categories. Another important subset is walking single accidents. The empirical relevance of this view was early pointed out. They demonstrated the importance of walking accidents to and from the bus when accounting the total safety of buses.

From a societal point of view this extension from traffic to travel is not enough. A calculation of the total losses due to a specific type of journey includes the **transport occupational accidents** which occur during the construction, maintenance and repairing of the transport subsystem in question. **Transport safety** includes the consideration of travel accidents and transport occupational accidents.

This extended safety conception is suggested in Graph 1. It includes an increasing number of accident categories.

Graph 1. The conceptions of traffic, travel and transport safety with regard to accident categories.

| SAFETY CONCEPTION | ACCIDENT CATEGORY: Road traffic accident | Track vehicle accident | Walking accident | Occupational accident |
|---|---|---|---|---|
| Traffic safety | + | | | |
| Travel safety | + | + | + | |
| Transport safety | + | + | + | + |

The road traffic accident concept does not cover all possible accidents on these five transport moments. Track vehicle accidents and walking accidents including assaults are not taken into account in that concept. Also accidents at sea and in the air could be mentioned, but as this study is concerned with land transportation and primarily with metropolitan travels, these accident types are not further discussed.

2.2.2 New accident concepts

The next step in formulating theory of transportation safety regards the importance of accident type. What kind of basic events constitute important unsafe transport conditions?

This approach highlights the encounter between transport subsystems. It puts the finger on a very popular view of the accidents in traffic and in transport, namely the conflict hypothesis. The relatively few severe casualties due to collisions between motor cars and also between cars and unprotected road users are much more important in terms of counter-measures than other types of accident casualties.

Statistics show however that car single accidents are frequent and that injuries are severe. This calls for a systematic treatment on behalf of every transport subsystem, whenever you have the societal perspective.

Each travel accident category consists of three basic types, namely **single** accidents, **internal interaction** accidents and **external interaction** accidents . There

Graph 2. The occurence of involvement-related-accident types in road traffic, track vehicle, walking and occupational accidents.

| ACCIDENT CATEGORY | ACCIDENT TYPE: Single accident | Internal interaction accident | External interaction accident |
|---|---|---|---|
| Road traffic accident | + | + | + |
| Track vehicle accident | + | + | + |
| Walking accident | + | + | + |
| Occupational accident | + | | |

is no kind of interaction at all from other traffic customers in the single accident type. The complex of causes are only refered to the customer and the environment. The user and other users of the same way of travelling and their respective vehicles are involved in internal interaction accidents . Environmental causes may contribute to the accident. The external interaction case regarding a specified accident category is characterized by the intrusion of vehicles belonging to other accident categories and users of another way of travelling than the transport system in question. This type of accident appear in as many cases as there are subsystems or modes studied. The conflict hypothesis stresses the importance of the internal and the external accident cases.

Transport system accidents include by side of travel accidents also occupational accidents. These accidents are regarded as more or less single accident cases. All these concepts may be classified as the roots of a transport safety theory, because it includes the safety of the traveller and of other travellers, as well as the safety of the economically active population in transport occupations.

The travel accident categories in Graph 2 are easily apprehanded as representing the transport subsystems of road vehicles, track vehicles and pedestrians. All travel accident categories are described by the same kinds of involvement from transport users. These categories are possible to redefine in the model building process.

## 3. MODELBUILDING

The accident categories of Graph 2 are redefined and refered to three transport subsystems. The accident types are applied to each subsystem. Relations are established between casualty frequency and exposure of users. In the interaction accident cases exposure to other subsystem users are added. A database which cover these single and interaction accident casualties is supplemented by exposure data. Data from this source are used for estimation purposes.

## 3.1 Model development

3.1.1. Interpretation of Smeed's formula

Models with increasing complexity are being developed, starting from Smeed's famous formula regarding traffic deaths presented in 1949. It is argued that his formula lacks theoretical content although it fits data fairly well. There is a possibility to interpret in in exposure terms.

His formula is expressed as D = 0.0003(N*P2 )1/3 where D is the number of traffic deaths in a country, P is the number of inhabitants and and N is the number of cars. This numerical expression is represented as a flow model of the Forrester type. The population P and the number of deaths D are represented by stocks which are joined by a flow of deaths per period controlled by a rate regulator. This rate is an expression of casualty risk, which is a funktion of road-user exposure P and exposure to car system N. The risk of death is assigned to both motorists and unprotected road-users. It applies to internal accidents within the first group and to external accidents regarding the second group.

This model is developed in a second step, by separating the motorists from the non-motorists. The number of deaths in traffic is now a sum of two separate accident processes. The frequncy of dead non-motorists is related to their movements and to the amount of motor vehicle traffic. This model handles only external accident casualties for the first group and internal accidents in the second group. Single accidents are not described.

A third simplified model is constructed. In this step, there are two transport subsystems, PMT and cars, which are mutual threats to their users.Flows of traffic customers are exchanged between the subssystems of PMT and cars. The distribution of customers is controlled through a transport policy, which is influenced by the outcome of casualties from each subsystem. Each level of casualties is a result of internal and external accidents. Single and occupational accidents remain to be included.

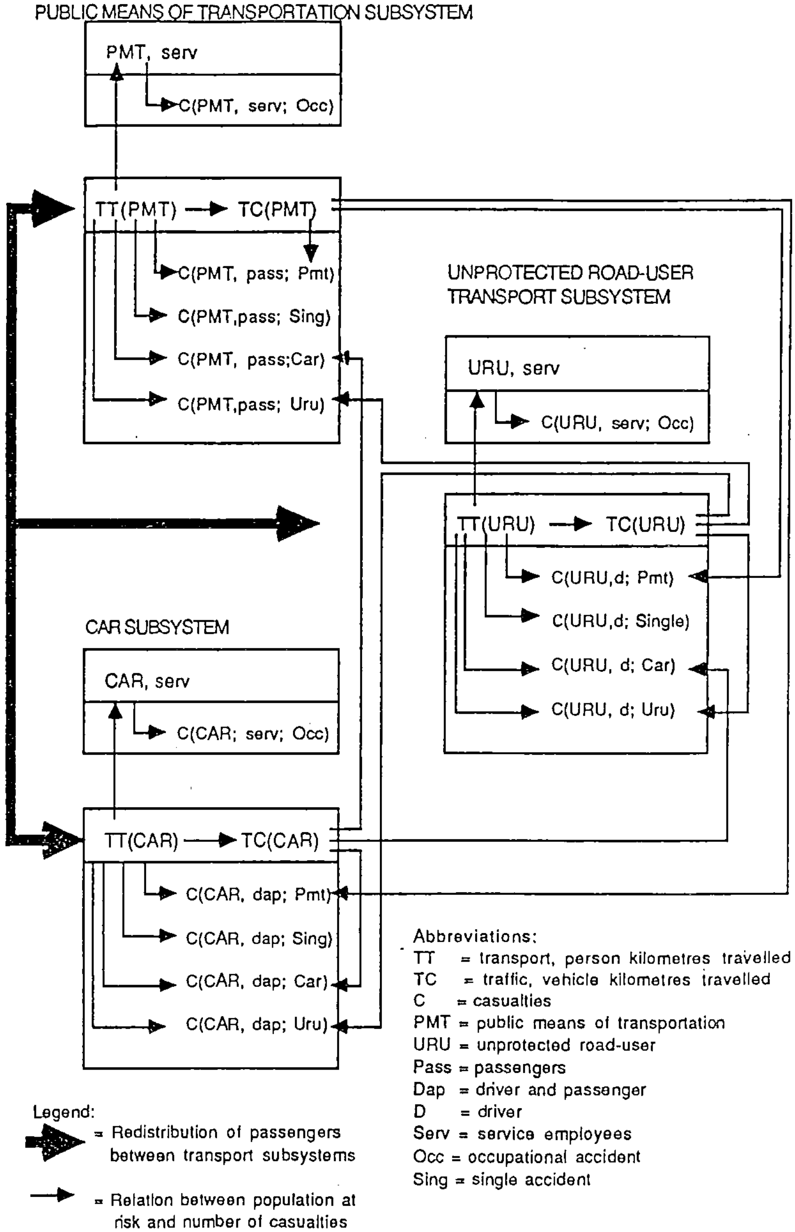
3.1.2. A three- transport subsystems model

An extended model is applied in this paper. The model describes the complex person transport system of an urban region consisting of PMT, cars and unprotected road-users. Unfortunately, there was no quantitative empirical base found to use as a feed-back to simulate a transport policy control. In each subsystem five different accident processes with accompanying personal injury occur.

- In the first process subsystem users are injured in interactions with vehicles of their own system.
- The second process produce single accidents.
- In the third and the fourth process, subsystem users interact with vehicles from each of the other two subsystems.
- Accident processes in the transport occupations are added to each subsystem.

In all there are fifteen accident processes, out of which nine are conditioned by the amount of traffic produced by some of the other subsystems. The whole system is described by fifteen equations of power-type. Nine of them depends on the exposure of two subsystems. Inputs in each subsystem are person-kilometres-travelled, vehicles-kilometres-travelled and casualty rates. These risks are calculated in order to consider all

Graph 3. An extended model of accidents and casualties in three transport subsystems



the transport moment accidents of a complete door-to-door travel chain, including walking. The parameter values are calculated from a database of commuting accidents in the capital region and the western parts of Sweden in 1971, which reflects the travel safety concept. The simulations presume a linear relationsship between the number of casualties and the amount of person-kilometres-travelled.

## 4. TESTING PROBLEMS

It has not been possible to test the model in the traditional manner. There is simply no relevant database available. To gather the relevant data would take a year or so and cost a considerable amount of money.

## 5. QUESTIONS OF SIMULATION RESULTS

Questions of loss variation arise. There is a long and a short range perspective on different distributions of user casualties by transport subsystem:

What is the appearance of the casualty distribution by PMT, cars and unprotected road-users (URU) during a total redistribution?

What is the marginal rate development of casualties when the share of public commuting is changing within the limits of ten percent ?

## 6. THE SIMULATIONS

### 6.1 The Stockholm Region

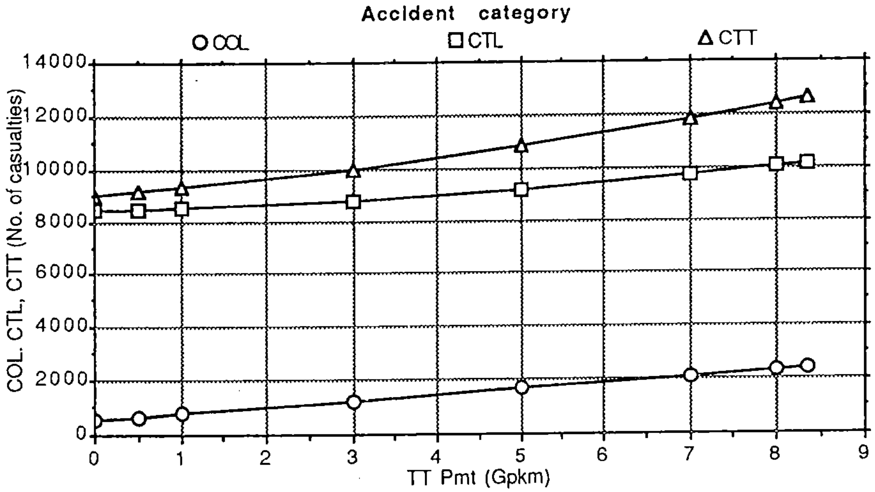
The case in mind is The Stockholm Region, which is the capital of Sweden and has around 1.4 million inhabitants. The city is equipped with a subway, a bus system and commuter trains. Around forty per cent of all personkilometres travelled is performed by PMT. The share of unprotected road-user travelling is nine per cent. It is kept unchanged during this simulation. Passengers are transfered from cars to PMT within a range of zero to 8353 Mpkm. In 1971 PMT-travel accounted for 3437, car for 4916 and URU for 865 Mpkm according to a travel survey this year.

The simulation proceeds from zero to a hundred per cent PMT-travellers. The number of transport casualties is increased from 9000 to 12500. How come?

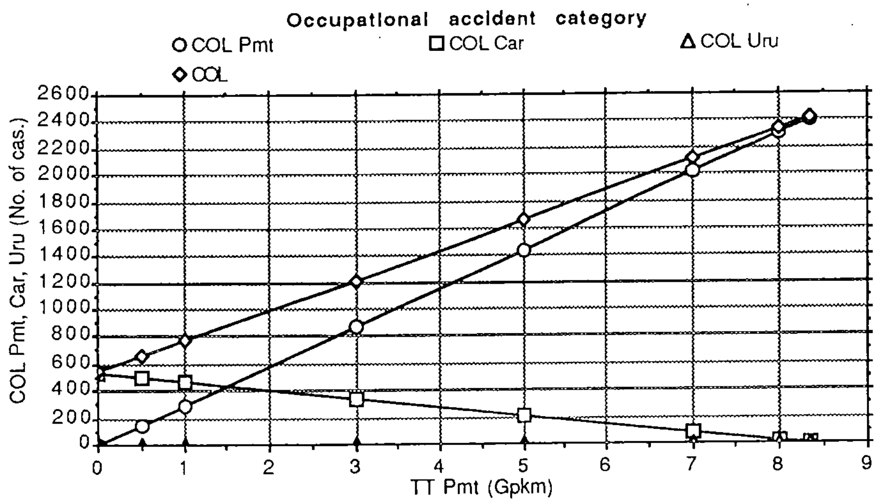
### 6.2 Results

Travel casualties constitute the great part of the total transport casualties. It is noticeable that all three casualty curves in Graph 5 are moderately bending upwards as the PMT-travel increases. The chart in Graph 6 of the occupational casualties distribution demonstrate the great importance of casualties in PMT-transport industries. Graph 7. The many travel accident injuries are primarily inflicted upon unprotected road-users. Only to a minor degree are their situation made less vulnerable when PMT- vehicles are in more frequent use. There is a steep raise in PMT-casualties as PMT-travelling is climbing high. Throughout the simulation the marginal growth of PMT-casualties in Graph 6 neutralizes the decreases of the car and URU-casualties. The single accident type is predominant irrespective of transport situation. Single accident casualties in Graph 8 constitute a component of high and rising importance to the overall casualties in this metropolitan region. In Graph 9 the distribution of PMT-casualties by accident type is described. Obviously, internal and external accidents are few, while single accidents totally dominate the picture. They constitute 5500 cases out of a total in the region of 12500.

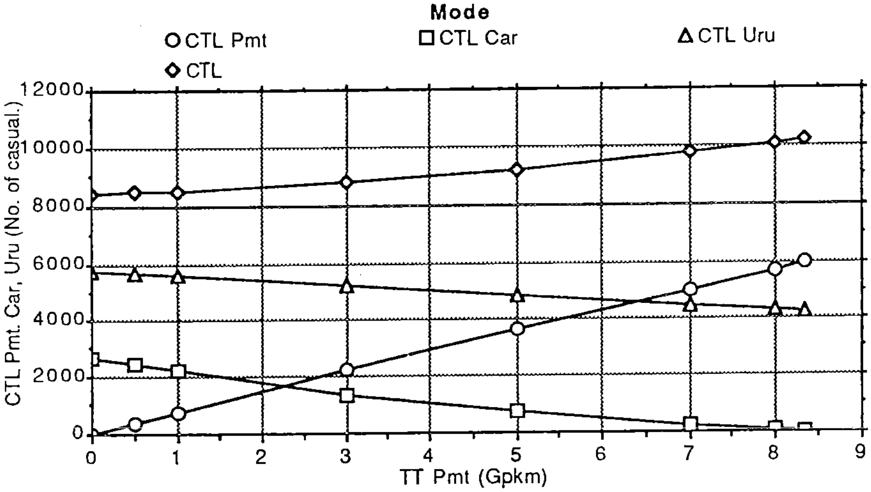
Graph 5. Simulated number of casualties in transport accidents in The Stockholm Region distributed by category.



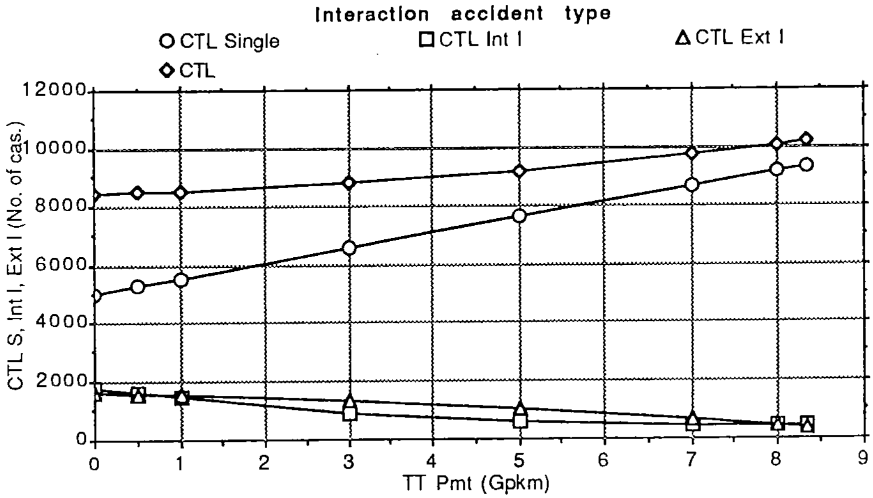

Graph 6. Simulated number of casualties in occupational accidents in The Stockholm Region distributed by category



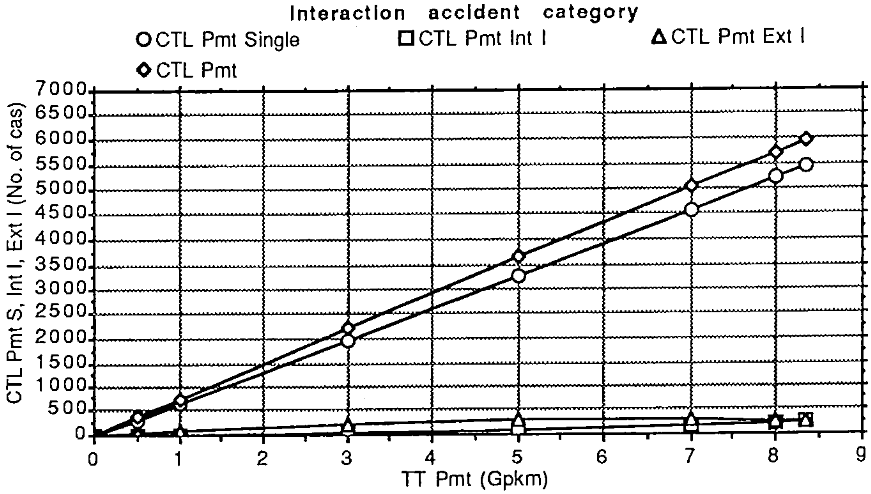
Graph 7. Simulated number of casualties in travel accidents in the Stockholm Region distributed by mode



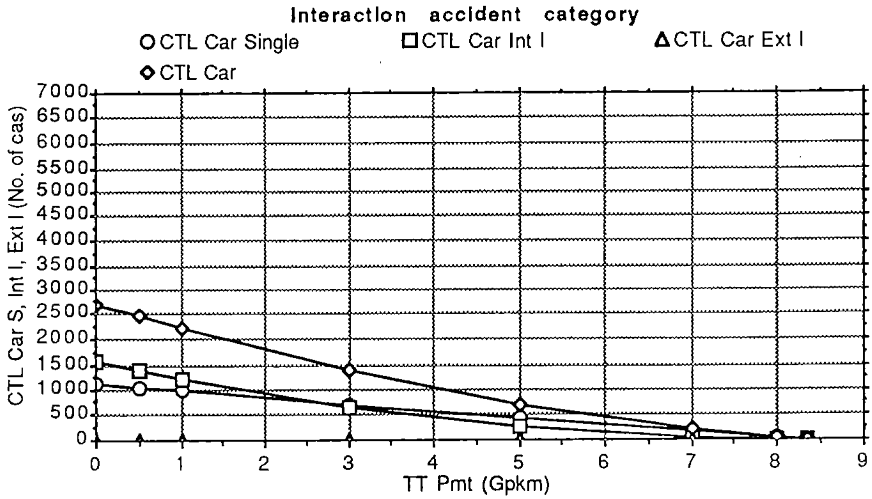

Graph 8. Simulated number of casualties in travel in The Stockholm Region accidents distributed by interaction type



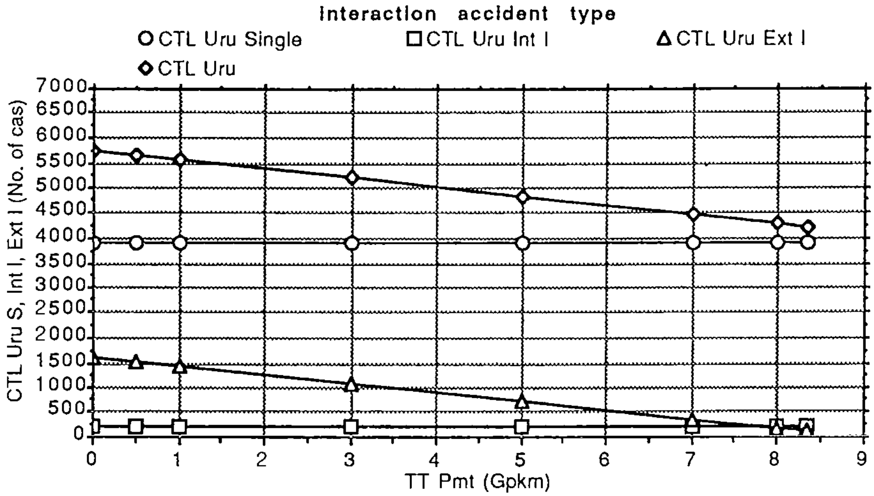
Graph 9. Simulated number of casualties in PMT-travel accidents in The Stockholm Region distributed by interaction category.



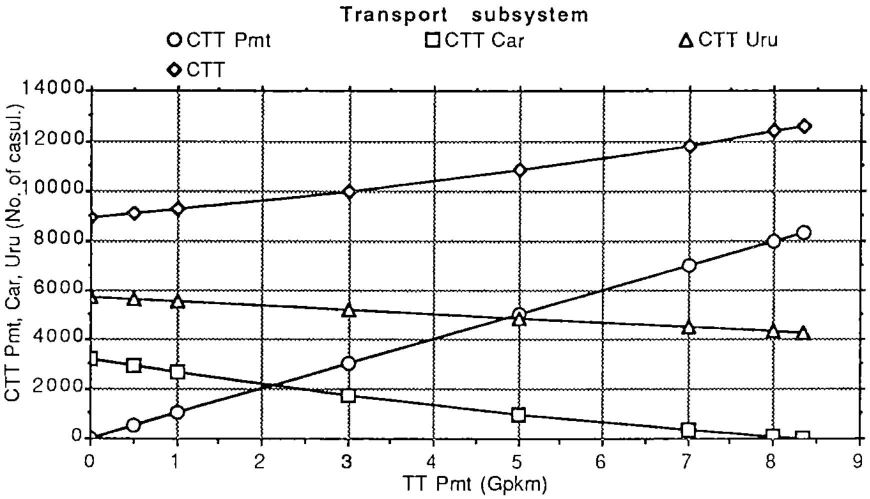

Graph 10. Simulated number of injuries and deaths in car travel accidents in The Stockholm Region distributed by interaction category



Graph 11. Simulated number of injuries and deaths in URU-travel accidents in The Stockholm Region distributed by interaction category




Graph 12. Simulated number of casualties in transport accidents in The Stockholm Region distributed by transport subsystem



Graph 10 shows car casualties. Only in the high density car conditions are the well-known collision accident injuries a majority among the relatively few car casualties.Perhaps surprisingly, in Graph 11 single accidents make up the great part of unprotected road-user casualties. They add another 4000 to the former named 5500, which means that single accidents makes three quarters of the total number of casualties.

Graph 12 presents the total casualty outcome.Travel and occupational casualties are distributed by mode of transport. The present transport pattern produces most casualties among unprotected road-users, PMT-travellers has place number two, while car occupants travel rather safe. Simulated patterns indicate possible future outcomes, which all imply that increased PMT-travelling is connected with growing casualty frequencies.

## 7 CONCLUSIONS

There are no substantial safety gains to be obtained by transferring a limited amount of road-users in total Sweden and in the metropolitan regions from cars to PMT. The long range redistribution cases have implications only to the model world. In the metropolitan regions safety is impaired uninterrupted during the whole redistribution. The model has laid the basis for simulations of theoretical safety variations due to modal changes.

## BIBLIOGRAPHY

Forrester J. Urban Dynamics. Cambridge Mass: MIT Press, 1969.

Forsström, Å. Commuting Accidents. A study of commuting accidents and casualties in some Swedish regions during 1971. Meddelanden series B No 69. Göteborg: Dept. of Human and Economic Geography, Univ. of Göteborg, 1982.

Forsström, Å. Simulation of casualties in Person Transport Systems. The variation of injuries due to changing customer distributions. Choros No 1990:4. Göteborg: Dept. of Human and Economic Geography, Univ. of Göteborg, 1990.

Haight, F.A. Research and theory in traffic safety. Contributions of the invited speakers. International symposium on traffic safety and research methods organised by SWOV in Amsterdam April 26-28 1988 The Netherland, 1988.

Jörgensen, N.O., Led, J.C. and Levi, P. Säkerhet.Nordkolt delrapport 4, Oslo: Nordiska ministerrådets sekretariat, 1974.

Smeed R.J. Some Statistical Aspects of Road Safety Research. Journal of the Royal Statistical Society, Ser. A, Vol CXII, Part I, pp1-34, London: 1949.

Traffic Injuries 1985 SOS. Stockholm: National Bureau of Statistics, 1988.

Whitelegg J. Road safety: defeat, complicity and the bankruptcy of science. Accid. Anal. & Prev., 15, 153-160. London: Pergamon, 1983.