Defining “accident scenarios” for collector rural roads

Losa, M.
Associate Professor – University of Pisa – Department of Civil Engineering - ITALY

Ristori, C.
PhD Student – University of Pisa – Department of Civil Engineering - ITALY

SINOPSYS

An accident prototypical scenario is defined as “a prototype of the accident process corresponding to a series of accidents which are similar in terms of the chain of facts and causal relationships found throughout the various accident stages”. This approach, which is based on the detailed analysis of accidents aimed at identify dysfunction in the sequence of events and causal relations, can be usefully applied for disaggregate analyses of road accidents.

Each accident prototypical scenario is composed of four phases:
- the driving situation (describing the general situation prior to the system dysfunction);
- the accident situation (identifying the event or conditions leading to critical conditions);
- the emergency situation (where the accident, in some cases, can be still avoided by means of extreme manoeuvres);
- the choc situation (which explains the type of impact and its consequences).

While this technique is used in French to identify the accident scenarios for urban contexts, the Authors do not know of works made by applying this concept in suburban and rural contexts.
In this research, the approach of the “accident prototypical scenario” has been applied to two rural road sections with different functional features; the analysis period is since 1998 to 2002.
Data of 446 analysed accidents have been extracted directly from Police reports. The analysis of data has highlighted two aspects to investigate:
1) accident scenarios used for urban contexts do not allow to classify all the accidents sampled on rural roads;
2) in existing accident scenarios, the description of the four phases has not been made always by using generalised rules and so some difficulties can arise in identifying the right scenario.
This considering, as first some general rules to describe accident scenarios have been defined; then, by using accidents collected on the two selected road sections, existing scenarios have been adapted and new accident scenarios have been identified for suburban and rural contexts. Besides, particular attention has been paid on causal factors, connected to road features, which could induce incorrect behaviours of drivers.
In conclusion, this technique has appeared to be helpful in identifying those defects connected to road features that can concur to cause road accidents.

Defining “accident scenarios” for collector rural roads

INTRODUCTION

One of the most effective approach to the analysis of the causal factors in road accidents and to understanding the influence of the road context is constituted by the study of accident events. It is well known that the analysis of accident data can involve two different levels of detail, although they are complementary to each other: a more general one (aggregate analysis) and a more specific one (disaggregate).
It is well known that disaggregate analysis evaluates in more depth the causal factors and the dynamics of groups of specific accidents. That is, sets of accidents that occurred in certain sectors of a study domain (Fleury et al., 1990) or sets representative of accidents that occurred by aleatory sampling (Brenac et al., 1996), similar in terms of the type of vehicles or the category of drivers involved (Tira et Brenac, 1999), in the location, in dynamics.
One of the disaggregate analysis techniques is based on “accident scenarios” and was developed in France at the end of the eighties as an alternative tool to collision diagrams, of Anglo-Saxon origin.
The most important novelty introduced by “accident scenarios” is that accidents are no longer grouped according to certain specific characteristics, for example, types of vehicles involved, road surface conditions, visibility, etc., as is the case with collision diagrams (which in any case represent a valid tool for reconstructing the history of accidents of a specific location), but according to deeper similarities, through the analysis of the accident dynamic.
Some extensive studies carried out on accident data have highlighted the importance of defining the time history of each accident event, in particular regarding the phases preceding the collision (Baker, 1960; OECD, 1984). Other technical-applied researches have stressed how the identification of multiple strategies for the prevention of road accidents is possible through the temporal segmentation of accident events (Andersson & Menckel, 1995; Haddon, 1980).
The accident scenario, defined as the prototype of an accident event to which can be referred a series of accidents that are similar to one another in the temporal sequence of events and in the relation between cause and effect (Fleury et al. 1987; Dansereau and Lupin, 1994; Tira and Brenac, 1999), constitutes the most concrete implementation of these ideas. The use of the term ‘prototype’ indicates that the “accident scenario” does not constitute an exact temporal reconstruction of the individual accident, but must provide a theoretical representation of the accident dynamic to which a series of accidents with similar general characteristics can be referred.

At present, such an approach is not very common for two reasons:

a) when speaking of accidents, an analytic approach has prevailed, aimed at identifying the ‘causal factors’ of events, that is, any circumstance without which the accident event could not have occurred. Although the latter approach can certainly be used for analysing single components of the system, it is not equally effective for analysing the overall accident event; otherwise an approach based on the analysis of the whole process leading to the accident event, that is, the temporal reconstruction of the dynamics, might make it possible to identify other elements that might have contributed to the occurrence of the accident itself;
b) Such a method is still excessively affected by the subjective component of whoever is carrying out the analysis, as regards both the method of identification of the scenario most “similar” to the accident analysed and the creation of new scenarios.

The aim of this paper is therefore to define some aspects that can create uncertainties about the methods of identification and construction of new scenarios and to illustrate the potentialities of this instrument of enquiry; moreover, through the application of this technique of analysis to accident data collected on two collector rural roads, we have tried to define a series of new scenarios that are characteristic of this type of infrastructure.

THE CONCEPT OF ACCIDENT SCENARIO

The basic principle of the sequential analysis of road accidents is that they always originate in a discontinuity of the process constituted by the travelling of one of the vehicles involved, which creates a rapid deterioration of the whole process and precedes by a few moments the impact with another vehicle or obstacle.
It is possible to subdivide this sequence more specifically by identifying two different discontinuity: the first is the one that brings about the crisis situation, which could in any case have been remedied, if there had been a prompt reaction on the part of one of the individuals involved; the second discontinuity is that immediately preceding the impact, that is, the failed reaction that could have avoided the accident. The entire sequence of the accident event can be reconstructed as illustrated in figure 1.

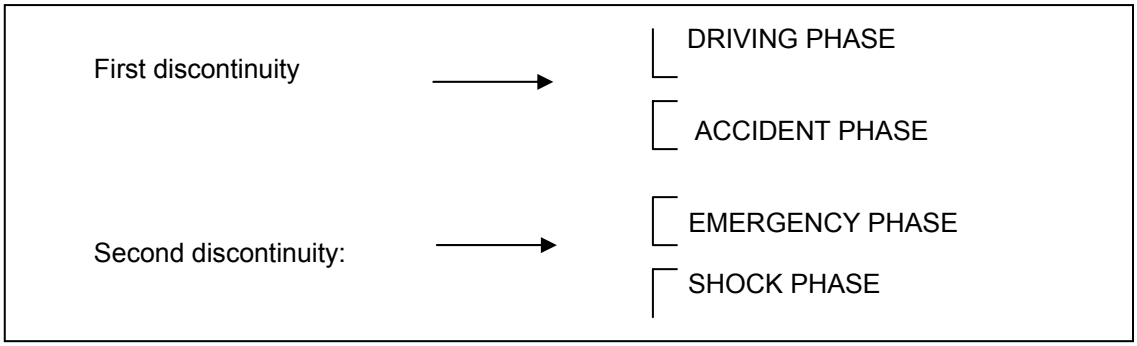

Figure 1: Subdivision of the temporal sequence of an accident in four phases, based on two different discontinuities

For the description of an accident scenario, it is not enough that one has to go beyond the simple structuring of the event into phases. It is also necessary to try to define a relatively simple and practical form in the procedure of reconstruction of the dynamics; indeed it is only in this a way that anyone is enabled to identify and create new scenarios.
The representation of the scenario prototype can indeed have different forms (purely textual, information on cases used for constructing the prototype, frequency of features defining prototype, identification of causal factors etc). However, no single method has yet been identified that is more effective than others for representation, in that each operator can find one method more effective than another.
As regards the information that has to be contained in an accident scenario, there is in the literature a useful document, a summary of which will be presented below. It was conceived for the drafting of possible curricula to be adopted in training courses for the French Police Force, involved in the reporting of road accidents, in the case that the classification technique based on accident scenarios will become of common use (Brenac, 1997). In this document, the content of each of the four phases is defined clearly and simply.

Driving situation: this is the phase in which general situation is described before the discontinuity occurs. The following must therefore be specified: what is the driver of the vehicle (or the pedestrian) doing before the discontinuity? On what kind of infrastructure is he/she travelling? At what speed is he/she travelling? Is the speed compatible with the other elements present at the scene? Does he/she execute a particular manoeuvre (for example: does he/she decelerate or does he/she execute a manoeuvre to turn left)?

Accident situation: this identifies the crucial element of the scenario, in that it describes the situation of danger that has been created because of the discontinuity. The reconstruction or creation of an accident scenario is based precisely on the identification of the first of the two discontinuities:

- the discontinuity must be defined according to a perspective that is external to the scene of the accident; in practice it must be reconstructed as it appears to the eyes of an impartial witness;
- it must be evaluated in relation to the whole scene of the accident, considering therefore all the components involved;
- it must be evaluated in relation to the time-space progression of the accident.

It is obvious that, because of the way it is identified, such a discontinuity is affected by the subjective component of the operator who interprets the accident and has to reconstruct the scenario. The operators must therefore have an adequate knowledge of this technique and experience in the reconstruction of the dynamics of the scenarios.

Emergency situation: this represents the moments during which the accident could still be avoided if the person who caused the discontinuity or the other persons involved in the accident executed appropriate

manoeuvres; the questions that can help to define this phase are therefore: does the person involved attempt an emergency manoeuvre? In particular, does he/she attempt to brake, swerve, or both? Can the manoeuvre cause a skid or a 180° spin? Are the wheels locked when the brakes are applied? Does the driver execute a manoeuvre despite the fact that the conditions are not such as to do so safely?

Impact situation: this makes explicit how the collision takes place, whether with another vehicle, an obstacle or a pedestrian. Useful questions might be of the type: how was the impact produced? With another vehicle, or an obstacle or a pedestrian? Were passengers thrown out of the vehicle? Did the vehicle leave the road?

PROCEDURE FOR THE CREATION OF ACCIDENT SCENARIOS

The study of the accident phenomenon in a given context can require the creation of new accident scenarios. The method adopted in much of the research conducted in France for the creation of accident scenarios (Fleury et al., 1987, 1990, 1991; Mercier, 1994; Brenac & Megherbi, 1996; Brenac et al., 1996; Brenac & Yerpez, 1997), and also used in this study, consists in the following stages:

1) collection of accident information from police reports;
2) study of the dynamic and identification of the temporal sequence of the four phases preceding the impact for each accident;
3) grouping into sets of accidents with similar characteristics;
4) creation of an accident scenario prototype for each group formed

The first stage of the procedure requires the acquisition of reports drawn up by the Police regarding accidents, since it is only in these that useful information for the reconstruction of the dynamic are contained, that is:

- the description of the dynamic made out by the police officer responsible for reporting the accident;
- testimony given by the parties involved and by the witnesses present at the moment the accident occurred;
- planimetric diagram illustrating the position of the vehicles after the collision (in cases where the vehicles were not removed before the arrival of the police);
- photographs of the vehicles and, possibly, of the scene of the accident.

In cases where certain details linked to the scene of the accident, in any case decisive for the reconstruction of the dynamics, are not sufficiently detailed in the report, it might be necessary to carry out technical on-the spot observations.
With such data, in the second stage, the main elements characterizing each accident are identified and described, so as to determine the dynamic objectively and possibly, in cases where the data are characterized by a lack of detail, to obtain reconstructions that are in any case reliable. In this phase of the analysis, the functional process of the accident event should be defined through the definition of the four phases described in the previous paragraph.
Subsequently, in the third stage, the accidents are grouped into sets adopting a procedure based on direct comparisons between two accidents at a time. The similarity between the two accidents is based on qualitative and global judgements; in this sense, two accidents are recognized as similar if the answer to the following two questions is affirmative:

a) is there an overall similarity between the two dynamics reconstructed?
b) can a correlation between the two accident events be identified?

If the answers are affirmative, the two accidents are included in the same set, whereas vice versa they will belong to different sets; extracting randomly one accident at a time from the sample of accidents, a comparison is then made with all the accidents of the various groups until that set is identified which best describes the accident in question.
Once the analysis of all the accidents has been carried out, the final stage of the procedure consists in constructing the relative accident scenario for each set. The variety of cases contained within each set makes it possible to identify the main, recurrent features linking the accidents, which can be used for the construction of the prototype.

THE DATABASE OF THE ACCIDENT SCENARIOS

The known applications of this technique of analysis to date regard only urban contexts; the most significant were carried out in France (Brenac et al., 1996; Tira & Brenac, 1999; Fleury & Brenac, 2000), for the study of road accidents occurring in some built-up areas (Bouches du Rhone and Salon de Provence). These studies focussed essentially on road accidents involving pedestrians and the aim of the studies was, in addition to

identifying areas characterized by a higher concentration of accidents, to determine the most suitable interventions to be implemented on the urban network to reduce the extent of the phenomenon. In both studies, although the effectiveness of the technique in its contribution to the identification of causal factors is confirmed, the need to broaden knowledge of such a technique and its validity in applications in different environmental contexts was emphasised.
In Italy, a study to publish the "Guidelines for the drawing up of the Plans for Urban Road Safety" has been carried out in 2001. It contains the description of the procedures to be adopted for an analysis of the accident phenomenon; in particular, it includes a database of 57 "accident scenarios", corresponding to all those known currently in the literature. The form adopted for these scenarios is of a textual type.
The database was used as a reference for the analysis of accident scenarios carried out on two collector rural roads within the work reported in this paper.

APPLICATION OF THE ANALYSIS TO TWO CASE STUDIES

General features of the road context

In this study, the accident scenario technique was applied to rural contexts by choosing two stretches of roads with different structural and functional characteristics, on the basis of the accidents recorded in the period between 1998 and 2002.

The first of the two stretches of road analysed is 11.5 km long and refers to an infrastructure that passes through an area with variable socio-economic characteristics, which are reflected inevitably in the function of the road. The road goes through four built-up areas where it takes on features typical of an urban context, with the presence of numerous socio-economic enterprises (shops, banks, bars etc.). It is about 42% of the entire stretch of road. However, on the stretches of road outside the built-up areas there are areas of significant commercial and industrial settlements with entrances often located directly on the road. The average volume of daily traffic is between 12,000 and 15,000 vehicles, about 10% of which are commercial vehicles. The highest percentage of journeys occurs over the entire stretch of the road, although a significant number of journeys within the stretch of road can be observed. The road is used essentially for journeys between home and work, with consequent high volumes of traffic throughout the year. The alignment presents anomalies only near three bends with a very small radius (< 100 m) and some bends characterized by reduced sight distance due to the presence of obstacles on the inner side (essentially threes). The transversal section varies according to the territorial contexts through which the road passes: indeed the width of the platform oscillates between 6.15 and 10.30 m. The stretch of road is also characterized by the presence of numerous at grade intersections and entrances to private properties, in total there are 42 intersections (three of which with traffic lights) and 69 entrances. This road is denominated "A".

The second of the two stretches of road analysed is 29.7 km long and refers to an infrastructure which passes through long sections in agricultural and forest contexts, with a low index of human settlement. The only stretches of road with significant human settlement are those passing through four built up areas, with a total length of 3.9 km, at distances of more than 5 km between them. The most significant productive settlements are located at the beginning and the end of the stretch of road and they do not however present direct access to the road, with only one exception. The built up areas that the road passes through all have less than 1,500 inhabitants and therefore they don't constitute significant origin/destination nodes for the transportation demand; in practice almost all the traffic on the road travels along the whole of the stretch in question. The average daily volume of traffic is about 5,000 vehicles, 10% of which are heavy vehicles. Although this infrastructure also has an important function for journeys between home and work, it should be pointed out that there are significant increases in demand during Sundays and holidays in the period from June to September, with peaks of daily traffic of up to 10,000 vehicles. The geometric features of the road present numerous anomalies, due essentially to the reduced width of the transversal section (constantly less than 8.50 m), to the presence of short-radius bends and/or with reduced visibility distance, located at the end of straight stretches, and in certain sections with poor planoaltimetric coordination. The number of intersections and entrances is very limited and they are concentrated around the built up areas along the road. Therefore, the stretch of road represents a typical example of a rural road. From now on, it will be denominated "B".

The choice of two stretches of road that are so different in terms of the function they perform, traffic volumes, economic and environmental context through which they pass, was determined by the wish to evaluate, in the first place, the applicability of the technique of accident scenarios to two types of very common infrastructures, and in the second place, the extent to which the scenarios known at present might be effective in different contexts from those in which they have been used to date.

Accident rate of the two infrastructures

The first stage of the study of the accident phenomenon characterizing the two stretches of road was the acquisition of the reports of accidents made in the period between 1998 and 2002 by the Road Police, the "Carabinieri" and the Municipal Police, under whose jurisdiction the areas being studied lay. Included in the sample were both accidents that had caused injury to people and accidents that had caused only damage to property: this made it possible to have a more statistically significant number of events, but also to understand better the actual extent of the two phenomena.
In total 446 accidents were acquired, of which 310 relative to road "A" and the remaining 36 accidents to road "B". Relating such values both to the length of the stretches of road and to the average volumes of traffic, the accident rate values obtained are respectively $1.14 \cdot 10^{-6}$ accidents per million vehicle·km for road "A" and $0.52 \cdot 10^{-6}$ accidents per million vehicle·km for road "B": the accident rate in the first is more than twice the second.
Considering only the accidents causing injury to persons, the average accident rate of the two stretches of road falls respectively to $0.73 \cdot 10^{-6}$ accidents per million vehicle·km for road "A" and to $0.26 \cdot 10^{-6}$ accidents per million vehicle·km for road "B". The difference between the rate values rises and the first is three times the second. This also shows a greater degree of hazard on the first road compared to the second.
From the analysis of such values, it emerges that the structural and functional differences of the two stretches are also reflected in the accident rate.

ANALYSIS OF ACCIDENTS WITH THE TECHNIQUE OF SCENARIOS

The first stage in the disaggregate analysis of accidents has been centred on the comparison between the typologies of accidents that emerged and the scenarios that make up the reference database. Indeed, although the samples of accidents used for the definition of the scenarios all refer to urban and suburban contexts, only some scenarios refer explicitly to such contexts (20 scenarios), while in the other cases they can also be applied without exception to rural roads. It was therefore necessary to verify whether the database was complete and suitable for the analysis of any type of infrastructure. It's known that the dynamic of accidents is conditioned by the type of territorial context (which in turn influences the level of attention and the accumulation of stress in drivers) through which the road passes, by the reason for the journey, by the characteristics of the road space.
From the preliminary analysis of the scenarios included in the original database, some not very clear aspects emerged. In the first place, there is no recognizable criterion in the codification adopted for the indices of the scenarios, given that the index used in the original version was probably maintained for each of them. Some scenarios present therefore a double index, which can be explained by the fact that analogous scenarios appear in various studies; some scenarios have a letter as an index while others a number. Moreover, scenarios referable to common situations (for example, referring to accidents occurring near intersections or private entrances) are not brought together in sequential order, but scattered within the database.
In the second place, the scenarios, probably because they were taken from various studies, not coordinated with one another, present a significant heterogeneity in the way of describing the individual phases, above all regarding the choice of perspective assumed. In some cases, indeed, the temporal sequence of the scenario takes as a reference the driver of the vehicle causing the accident, in others, the user who is involved in the accident following wrong manoeuvres executed by other drivers; again, in other cases the vehicle is used as reference, even though the manoeuvre is directly imputable to the driver.

The definition of a procedure that makes it possible formerly to construct scenarios univocally, represents therefore a step of fundamental importance towards being able to apply this technique to real cases and to create valid new scenarios for those groups of accidents that cannot be referred to any of the scenarios indicated in the database.

In conclusion, it can be said that such uncertainties constitute an obstacle to the wider use of this technique of analysis. Indeed, although the operation of grouping of accidents into sets on the basis of an overall similarity constitutes a more logical and rational way of classifying accidents, the current form adopted does not make its application easy or objective. In this sense there are in the literature some studies that have tried to codify the sequence with which to build the scenarios objectively (Clarke et al., 1995), although, as the database shows, with unsatisfactory results. Therefore, in the following paragraphs, as well as defining criteria for the composition of the individual phases, some explicatory examples of the complete database attached to the present paper are illustrated, including all the scenarios identified during the study.

DEFINITON OF THE METHOD FOR THE CREATION OF NEW ACCIDENT SCENARIOS

In the light of the observations made in the preceding paragraphs, it was considered necessary, before starting the analysis of the accidents forming the study case, to define criteria to be adopted for the classification of the scenarios, for the creation of new scenarios and for the modification of the existing ones.

Formal aspects for the description and indexing of the accident scenarios

In place of a discursive form for describing the individual phases, it is considered more effective to adopt a synthetic form, with a list of points and with a limited number of typical phrases that, combined appropriately, made it possible to create numerous different scenarios. In particular, the choice of using lists of points constitutes a preliminary step for the creation of block diagrams necessary for a computerized implementation of the scenarios. It is indeed believed that the technique of accident scenarios can be used to classify accidents more automatically and objectively by using software. This tool, based on an initial database consolidated by numerous applied experiences and using assigning procedures based on cluster analysis algorithms, makes it possible to associate the accident being examined with the scenario already contained in the database or to create a new one.
As far as the method of indexing the scenarios is concerned, it was considered opportune to adopt a double index. The first, more general, representing the group of scenarios that were similar in terms of type of impact or the scene of the accident and the second, more specific, to distinguish from one another the scenarios belonging to the same group. Eleven groups were identified, taken in part from the above-mentioned document of a pre-norm character. However, with respect to those contained in the same document, the classification relating to the accidents occurring around the intersections was more detailed. Instead of a single group, 4 distinct groups were defined according to whether the accidents occurred near to intersections, respectively, at grade, with traffic lights, roundabout or interchanges; moreover, a specific group was defined for all those scenarios characterized by very particular dynamics not referable to any of the other groups.

The eleven groups of scenarios refer to:
1) accidents with an isolated vehicle;
2) accidents linked to the overtaking manoeuvre;
3) accidents due to lane change manoeuvres;
4) accidents occurring at entrances or at grade intersections regulated with right of way;
5) accidents occurring at grade intersections with traffic lights;
6) accidents occurring at intersections with roundabout;
7) accidents occurring at interchanges;
8) rear end accidents;
9) accidents linked to parking manoeuvres;
10) accidents involving pedestrians;
11) accidents of another type not referable to any of the groups of scenarios.

From a preliminary examination of the groups presented above it might be thought that the assigning of some scenarios to the various groups is uncertain. Let us consider, for example, the cases of rear end accidents that occurred on a stretch of road approaching an intersection: in general one can identify 2 or 3 different scenarios that are representative of these accidents; they could belong both to group 4 (for the accidents occurring near intersections or entrances) and to group 8 (rear end accidents). In this sense, it is specified that the scenarios belong to group 4 when their dynamics is correlated to the manoeuvres necessary at an intersection or entrance (turns, crossings and lane changes); while in all other cases, the scenarios are included in-group 8.
This preliminary classification is useful because it facilitates the activity of the operator who must identify the scenario that is representative of the specific accident; indeed, based on general analysis of the dynamics, the operator is at least able to identify the group it belongs to, within which to find the scenario that reproduces the greatest overall similarity. In this way, the number of comparisons that have to be carried out is reduced.
A cardinal number represents each group from one to eleven, following the order in which they have previously been listed. Thus, each accident scenario is identified with a numerical code of the type *aa-bb*: the first number, *aa*, indicates the group to which the accident scenario belongs, while the second number, *bb*, refers to the specific scenario belonging to class *aa*.
A final aspect to be considered is the determination of which phases determine the overall similarity of a group of accidents. It is, indeed, well-known that analogous driving situations rendered critical by analogous types of error can bring about subsequent situations that differ considerably from each other according to whether the driver of one of the vehicles involved attempts an emergency manoeuvre or not. In this sense, it

is considered appropriate to evaluate the overall similarity based on the first of the two phases of the scenario and to identify the possible alternatives in the phases of emergency and shock. This choice is determined by the belief that a profitable use of this technique is possible only if the number of scenarios can be contained as far as possible.

Description of the driving phase

The description of the driving phase must specify the following points:

- the manoeuvre being executed by the vehicle denominated with the index A, corresponding either to the vehicle that is the cause of the accident (in the case of scenarios referring to accidents occurring with isolated vehicles) or that plays a passive role in the accident. The type of vehicle (for example, two-wheeled vehicle, or heavy vehicle, etc.) must also be specified, only in cases where the identification of the vehicle with that particular category is statistically significant;
- the manoeuvre being executed by the vehicle denominated with the index B, indicating the vehicle that generates the discontinuity, before the process leading to the accident is initiated. In the case where the scenarios refer to accidents with more complex dynamics, the other vehicles involved are identified with the successive alphabetical indices (C,D,E, …);
- the type of driver of vehicle A (in the case of scenarios referring to accidents with an isolated vehicle) or more in general of vehicle B. Such details must specify whether the drivers are young, old or inexpert and should be included only if this information is significant in the identification of the scenario; vice versa, if the scenario refers to accidents that can involve any category of driver, such information is omitted.
- traffic conditions, if the scenario is directly affected by the presence of heavy traffic;
- geometrical and structural features of the stretch of road of particular importance for the dynamics;
- environmental conditions, if the scenario occurs with a higher probability in particular weather or road surface conditions;
- The context, if there are elements of particular importance.

The last aspects mentioned must highlight possible causal factors linked to the infrastructure; in this way, the use of scenarios can constitute a valid auxiliary instrument for the identification of possible defects that could have contributed to the occurrence of an accident.
The description of each single item must be in brief, concise sentences, as can be seen from the scenarios shown in the appendix.

Description of the accident phase

The description of the accident phase proves to be, of the four, certainly the most delicate; previously, by assuming different points of view, the discontinuity can be attributed to different causal factors. To get round this problem, it was decided to concentrate attention on vehicle B or on its driver.
Sometimes the identification of the discontinuity can cause indecision in the operator carrying out the analysis. Let us consider, for example, the case, very common moreover, of accidents with the following dynamic: a driver, who has stopped on a secondary road, waiting to turn into the main road, decides to execute the turning manoeuvre; the result is the collision with another vehicle on the main road.

In the temporal sequence of this case, two different situations can be identified:
a) the driver is not aware of the stop or right of way sign;
b) the driver is aware of the presence of the road signs and slows down or stops.
These two situations require a separate analysis and must have two different scenarios as prototypes.
Focussing on the second situation, a sequence characterized by two critical moments can occur:
1. the first, in which the driver of the vehicle that has to turn into the main road is not aware of the vehicle approaching on the main road;
2. the second, immediately following, is when the driver initiates the turning manoeuvre.

The two moments are linked to each other in that the second, which identifies the manoeuvre that gives rise concretely to the crisis in the running process of the two vehicles, would not have occurred, if the driver had not first had the mistaken perception of being able to effect the entry manoeuvre. This manoeuvre is therefore a consequence of an error committed previously. Such an approach leads to the identification of the discontinuity in the mistaken perception of the approaching vehicle on the part of the driver that has to turn into the main road.

In other cases, a scenario can be more detailed and complex in the description of the discontinuity. Consider, for example, a vehicle that, approaching a pedestrian crossing, decides to begin to overtake a vehicle that is stationary or slowing down. In this case it can happen that pedestrians are present on the

zebra crossing or that the vehicle in front is about to move off again. The occurrence of one or the other possibility leads in the first case to the vehicle running over the pedestrians, with often serious consequences for the latter, or to the vehicle crashing into the vehicle in front, generally causing damage only to property. In this case the choice can fall either on two different scenarios that describe the two situations, or a single scenario characterized by a more detailed and complex description of the accident phase. It should be noted that in both cases it is always the driver approaching from behind that does not evaluate correctly what is happening in front of him/her.
For the description of such a phase, of fundamental importance is the evaluation of the statements made by the parties involved, by any witnesses and above all by the reconstructions carried out by the police officers that make out the reports. However, the first of these, in the majority of cases, are characterized by an evident partiality, while the reconstructions effected by the police might not be clear or exhaustive and often, in the case of controversies, leaves the definition of the cause of the accident to higher bodies. This aspect constitutes the weak point of the entire procedure and the causes can be due to many factors, such as carelessness in the compilation of the reports and the inadequate training of some police officers responsible for reporting accidents, as well as the different levels of awareness of the different bodies of the Police with respect to road accident reporting. In this phase, it should be emphasized that it is indispensable that accident reports are available, since without them it is impossible to carry out this type of analysis. In cases where there are obvious uncertainties it is up to the operator to try to interpret the information available and identify the most likely dynamic of the accident, by means of, among other things, on-site investigations.

Description of the emergency phase

This phase must describe which manoeuvre, had it been effected, could have made it possible to avoid the accident, identifying an essential temporal moment, i.e. the one that represents the second discontinuity in the travelling process. In general there are essentially 5 possibilities that can occur in this phase:

1. the driver causing the discontinuity does not react;
2. or reacts late;
3. the driver of the vehicle who is involuntarily involved in the accident does not react;
4. or reacts late;
5. the driver or drivers do not have time to react.

In actual fact, each scenario can present one or more of the options above. Let us consider again the case of the scenario that represents accidents that occur following the manoeuvre to turn into a road with right of way from a secondary road or from an entrance, after the driver about to effect such a manoeuvre fails to evaluate correctly the position of the vehicle travelling on the main road. The emergency phase regards both:

- the driver of the vehicle coming from the secondary road in that:
  - he/she effects the turning manoeuvre (that is, there is no reaction on the part of the driver);
  - he/she stops the vehicle when the other vehicle travelling on the road with right of way is by now at too reduced a distance (late reaction);
- the driver travelling on the main road, in that:
  - he/she does not effect any manoeuvre;
  - he/she effects a change in direction (that is, attempts an emergency manoeuvre) causing the collision with an obstacle or with a third vehicle.

For the definition of this phase the planimetric diagrams attached to the accident reports are particularly useful: these show any signs of braking, skid-marks etc., indicative of manoeuvres effected in an attempt to avoid the collision.

Description of the shock phase

The shock phase also presents a similar structure to the previous phase, with a moderate number of possible alternatives. In general, the following nine cases can be identified:

1. the vehicle that causes the discontinuity crashes into another vehicle,
2. or an obstacle,
3. a pedestrian,
4. in a multiple manner (meaning that the vehicle collides with more than one vehicle, with other vehicles and obstacles, etc. sometimes giving rise to a chain process);
5. the vehicle involved in the accident crashes into the vehicle that is the origin of the accident,
6. or, to avoid it, crashes into a third vehicle,
7. an obstacle,
8. a pedestrian,
9. or again gives rise to a multiple collision, with a similar meaning to that specified above.

The information necessary for describing this last phase of the scenario is represented by the description of the damage caused to the vehicles involved or to road elements (vertical signs, side barriers, etc.) or to other obstacles.

DESCRIPTION OF THE COMPLETE ACCIDENT SCENARIO DATABASE

From the analysis of the entire sample of accidents, based on the criteria mentioned in the previous paragraph, it was possible to create a total of 60 scenarios, subdivided into 9 of the 11 groups indicated previously. No scenario belonging to groups 6 and 7 were reconstructed, since there are no roundabouts or interchanges in the examined stretches of road. The number of scenarios contained in each group is indicated in the following table 1.

Table 1 – Number of scenarios contained in each group

GROUP OF ACCIDENT SCENARIOS	*N° of SCENARIOS CONTAINED IN THE GROUP*
1 – Accidents with an isolated vehicle	*11*
2 – Accidents linked to the overtaking manoeuvre	*4*
3 – Accidents due to lane change manoeuvres	*6*
4 – Accidents occurring at entrances or at grade intersections regulated with right of way or accidents occurring at grade intersections with traffic lights;	*13*
5 – Accidents occurring at grade intersections with traffic lights	*4*
8 – Rear end accidents	*6*
9 – Accidents linked to parking manoeuvres	*6*
10 – Accidents involving pedestrians	*5*
11 – Accidents of another type not referable to any of the groups of scenarios	*5*

Some of the scenarios are common to both stretches of road, while some are specific of accidents occurring on road “A” or “B” (table 2).

Table 2 – Subdivision of scenarios for each strech of road

Group of scenarios	*Scenarios specific of Road “A”*	*Scenarios specific of Road “B”*	*Scenarios specific of “both”*
1	5	2	4
2	1	0	4
3	5	1	0
4	9	1	3
5	4	0	0
8	1	1	4
9	2	1	3
10	4	1	0
11	1	4	0

By analysing table 2 closely, it can be observed that the highest number of accidents recorded on road “A” occurred near to intersections or entrances. They are followed by accidents with an isolated vehicle and those involving rear end collision; the remaining classes of scenarios present considerably lower values.
On the other hand, on road “B” the highest number of accidents occurred with an isolated vehicle; of equal significance is the number of accidents that involve rear end collision and those occurring near intersections or entrances, although represented by a smaller number of scenarios. As there are no intersections with traffic lights on this stretch of road, there are no accidents in scenario group 5.

Other aspects to which attention should be drawn refer to the comparison between the new constructed database (shown in the appendix) and the reference database. In practice, although the two databases are completely different from a formal point of view in the description of the 4 phases, many of the scenarios of the reference database were confirmed in the new one. Table 3, for each group of scenarios, indicates the number of scenarios confirmed and the number of the scenarios that had to be constructed *ex-novo*.

Table 3 – Comparison between the two databases of scenarios

Group of scenarios	*N° of existing scenarios*	*N° of new scenarios*
1	9	2
2	3	1
3	3	3
4	6	7
5	1	4
6	--	--
7	--	--
8	5	1
9	3	3
10	4	1
11	1	4

It emerges from the table that most of the scenarios had already been identified with the previous experiences; however, following this application a significant number of new scenarios were identified, showing therefore that the type of infrastructure and the context through which the road passes have a certain influence on the overall accident scenario.

GIS REPRESENTATION OF THE SCENARIOS

The effectiveness of the technique applied to road stretches or networks can be enhanced by means of GIS tools. In practice, all the accidents collected, classified with the accident scenario technique, were introduced into a simple-structured computerized database. Using the programme Arc View 3.2, the accident database was associated with the polyline representing the road; this association was carried out automatically by implementing the programme to transform a simple polyline into a polyline with a curvilinear abscissa representing the chainage. The precision of the accident localization was guaranteed by the previous verification of the position of each accident, by means of on-site investigations.
In figure 2 is reported an example of a possible association between the accident database of road “A” and the polyline representing the stretch of road. From this figure, it is possible to highlight more clearly sites characterised by higher number of accidents.

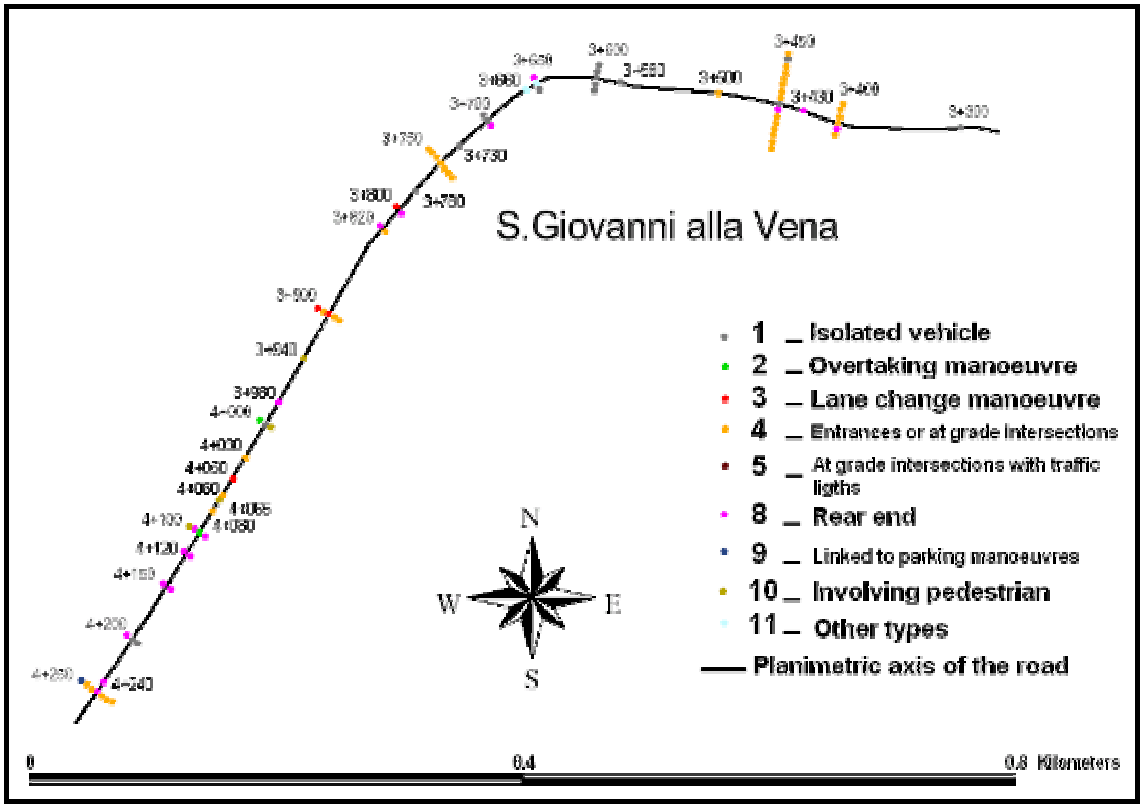

Figure 2: Example of G.I.S. application to accident analysis

CONCLUSIONS

This study has focussed on three main aims:

a) to improve some formal aspects of the application of the technique of disaggregate analysis of the accident phenomenon by means of the accident scenario technique;
b) to highlight the possibility of extending the use of the technique to suburban and rural roads;
c) to illustrate the advantages that can be obtained from the identification of the causal factors of road accidents linked to infrastructural defects;

The article is therefore divided into two parts. The first is aimed at defining those aspects still deficient in the application of accident scenarios; the second, on the other hand, is centred on the application of the method, with the use of accident data recorded on two stretches of rural roads, with very different features, in order to define a series of new scenarios.

It emerged therefore from the study that:

1. the technique is particularly effective in identifying the causal factors of road accidents, with particular reference to infrastructure deficiencies;
2. the technique is also especially suited to the disaggregate study of accidents on rural road networks;
3. it is necessary to implement the technique on other roads so as to identify more accident scenarios; so it will be not limited to particular contexts (e.g. urban contexts), but it will be broadened to include main rural roads and/or motorways;
4. the GIS representation of results makes it possible to highlight more clearly certain problems linked to the distribution of the accident phenomenon in a given area;
5. finally, it is necessary to investigate further the question of the creation of new types of software for the management of accident databases so as to classify them on the basis of accident scenarios.

REFERENCES

Andersson R., Menckel E. (1995), *On the prevention of accidents and injuries, a comparative analysis of conceptual frameworks, Accident Analysis and Prevention 27,* pp. 757 – 758.

Baker J.S. (1960), *Experimental case studies of traffic accidents: a general discussion of procedures and conclusions,* Northwestern University Traffic Institute, Evanston, ILL.

Brenac T. (1997), *L'analyse séquentielle de l'accident de la route (Méthode INRETS), Project n° Axe 3 – 1,* Department of Accident Mechanism Analysis, pp. 1 – 79.

Brenac T., Decam J., Pelat S., Teisserie G. (1996), *Scénarios types d'accidents de la circulation dans le dèpartment des Bouches du Rhone, Rapport MA 9611 – 2.*

Brenac T., Megherbi (1996), *Diagnostic de sécurité routière sur une ville : intérêt de l'analyse fine procédures d'accidents tirées aléatoriement, Researche Transports Sécurité 52,* 59 – 71.

Brenac T., Yerpez J. (1997), *Accidents impliquant des piétons : scénarios types obtenus à partir d'analyses fines de cas,* Proceedings of the Colloque européen sur les usagers vulnérables dans la circulation, Vulnerabilis 1997, Lyon, 14 – 15 January.

Clarke D.D., Forsyth R., Wright R. (1995), *The analysis of pre-accident sequences (TRL Contactor report 305),* Transport Research Laboratory, Crowthorne.

C.N.R. (2001), *Linee guida per la stesura dei Piani della Sicurezza Stradale Urbana*, pp. 58 – 67.

Dansereau P., Lupien C. (1994), *Scénarios d'accidents et conditions environnementales,* 29éme Congrès Annuel de l'AQTR, Quebec, pp. 65 – 79.

Depres S. (1998), *Recueil et analyse de scénarios génériques d'accidents, constitution et modélisation de scénarios consensus,* Actes de la conférence 'Ingéniérie et connaissances 98', Paris, pp. 231 – 241.

Fleury D., Brenac T. (2001), *Accident prototypical scenarios, a tool for road safety research and diagnostic studies, Accident Analysis and Prevention 33,* pp. 267 – 276.

Fleury D., Fline C., Peytavin J.F. (1987), L*es accidents de poids lourds, analyse des dossiers de l'Etude Détaillée d'Accidents, Recherche sur les Transports et leur Sécurité 14,* pp. 31 – 39.

Fleury D., Fline C., Peytavin J.F. (1990), *Diagnostic de sécurité sur un département, application au cas de l'Eure Détaillée d'Accidents, Recherche Transports Sécurité 14,* pp. 31 – 39.

Haddon W. (1980), *The basic strategies for reducing damage from hazards of all kinds, Hazard Prevention 16,* pp. 8 – 11.

Mercier A. (1994), *Les accidents de la circulation au droit des chantiers routieres, Revue Générale des Routes et Aérodromes 715,* pp. 25 – 29.

OECD (1984), *Targeted road safety programmes, Road Transport Research Programme,* OECD, Paris.

Tira M., Brenac T. (1999), *Scenari di incidente stradale e cartografia per la gestione urbana, Trasporti Europei 12,* pp. 7 – 18.

ACKNOWLEDGEMENTS

The Authors wish to thank the Pisa Province Road Administration for financially supporting this work.

APPENDIX: NEW ACCIDENT SCENARIOS FOR COLLECTOR RURAL ROADS

SCENARIOS FOR ONE-WAY OR TWO-WAY RURAL ROADS						
CODE	**Study road**	**DRIVING PHASE**	**DISCONTINUITY**	**EMERGENCY PHASE**	**SHOCK PHASE**	**Ref. DB**
Group 1: accident with isolated vehicle						
1-01	Both	_ Driver, generally inexpert or elderly, of a vehicle A. _ Section of road near bend or direction change. _ Often in particular atmospheric conditions.	The driver effects the manoeuvre at too high a speed.	Vehicle A: _ loses road holding and swerves; _ crosses over into the lane for oncoming traffic.	Vehicle A: _ crashes into another vehicle B; _crashes into an obstacle; _ leaves the road; _ is involved in a multiple collision.	***1; F;***
1-02	Both	_ A vehicle A in motion.	The driver: _ dozes off at the steering wheel; _ loses control for another reason, sometimes not verifiable or not verified.	The driver does no react.	Vehicle A: _ crashes into another vehicle B; _ crashes into an obstacle; _ leaves the road; _ is involved in a multiple collision.	***8; 7***
1-03	A	_ A vehicle A is travelling at a high speed. _ Conditions of poor visibility.	The driver is not aware of the presence of an obstacle on the road.	The driver: _ does not react; _ reacts late.	The vehicle A crashes into the obstacle.	***11;***
1-04	Both	_ A vehicle A in motion. _ Often particular atmospheric conditions.	_ Vehicle A loses grip on road. _ The vehicle is out of control.	The driver does not react.	The vehicle A: _ crashes into a vehicle B; _ crashes into an obstacle; _ leaves the road; _ crashes into more than one vehicle/obstacle.	***3;***
1-05	A	_ A vehicle A in motion. _ Often around dawn or sunset.	The driver of vehicle A is dazzled: _ by the sun; _ by the headlights of a car approaching from the opposite direction; _ by another source of light.	The driver is not able to perceive: _ the correct trajectory; _ the presence of an obstacle on the road.	The vehicle A crashes into: _ another vehicle B; _ an obstacle.	*--*
1-06	A	_ Driver of vehicle A, inexpert and/or under the influence of 'alcohol or drugs. _ Often at night.	The driver: _ executes a sudden turning manoeuvre ; _ loses control of the vehicle.	The driver does not react.	The vehicle A crashes into: _ another vehicle B; _ an obstacle.	***5; G, 6;***
1-07	Both	_ Driver, often inexpert, riding a two wheel vehicle A. _ Often on rough surface.	The driver rides the vehicle : _ with lack of care (e.g. using one hand only); _ at a high speed.	The driver of the vehicle is not able to control the vehicle.	The driver of the two wheel vehicle: _falls; _ crashes into another vehicle B; _ crashes into an obstacle.	***34;***
1-08	A	_ Driver, often young and inexpert, driving a vehicle B. _ Vehicle A travelling along main road with right of way. _ Stretch of road close to an intersection with stop sign. _ Often at night.	The driver of vehicle B dos not perceive the presence of the intersection.	The driver of vehicle B: _ does not react; _ reacts late.	Vehicle B crashes into: _ vehicle A; _ an obstacle; _ more than one vehicle/obstacle.	***22;***
1-09	A	_ A vehicle A is in motion. _ Often near to an intersection.	The driver is distracted by secondary information.	The driver: _ does not perceive; _ perceives late; the presence: _ of an obstacle; _ of another vehicle.	The vehicle A crashes into: _ the obstacle; _ another vehicle B; _ more than one vehicle/obstacle.	***9;***
1-10	B	_ A vehicle A, often a heavy vehicle, is travelling on the right side of the road. _ narrow section of the road. _ Right shoulder of road covered with dense vegetation.	The drive is not aware of driving on the edge: _ of the embankment; _ of a kerb;	The driver of vehicle A: _ does not correct the trajectory of the vehicle; _ corrects the trajectory of the vehicle late.	The vehicle ends up in the slope; often crashes into an obstacle present there.	*--*
1-11	B	_ A vehicle A is in motion. _ A vehicle B, often heavy, is travelling in the opposite direction to A. _ Narrow stretch of road, near a bend.	Vehicle B while on the bend invades the opposite lane.	The driver of vehicle A: _ loses control; _ attempts an emergency manoeuvre.	Vehicle A: _ crashes into vehicle B or another/ other vehicle/s C, D, etc; _ crashes into an obstacle; _ leaves the road; _ is involved in a multiple collision.	***2; F;***

Group 2: accidents linked to the manoeuvre to overtake						
2-01	Both	_ A vehicle A is in motion and is about to turn left. _ A vehicle B, often two-wheeled, is behind vehicle A. _ Presence of an intersection or access. _ Presence of traffic jams.	The driver of vehicle B fails to notice the manoeuvre initiated by vehicle A.	The driver of vehicle B: _ initiates manoeuvre to overtake; _ tries to avoid the vehicle in front.	The vehicle B crashes into: _ vehicle A; _ another vehicle C; _ an obstacle.	**--**
2-02	Both	_ A vehicle A, often two-wheeled is overtaking a queue of vehicles in motion. _ A vehicle B is behind in the line.	The driver of vehicle B: _ fails to notice that vehicle A is approaching; _ does not evaluate correctly the position of vehicle A.	The driver of vehicle B initiates the manoeuvre to overtake.	A vehicle runs into the other vehicle.	***33;***
2-03	Both	_ A vehicle B is travelling inside a queue. _ A vehicle A is travelling in the opposite direction to vehicle B. _ Short straight stretch with poor conditions of visibility.	The driver of vehicle B: _ fails to notice that vehicle A is approaching; _ does not evaluate correctly the position of vehicle A.	The driver of vehicle B executes the manoeuvre to overtake.	A vehicle crashes into: _ another vehicle; _ an obstacle; _ more than one vehicle/obstacle.	***40;***
2-04	A	_ A vehicle A is in motion. _The vehicle is about to overtake a vehicle in front. _ Often particular atmospheric conditions.	The driver effects the manoeuvre incorrectly.	The driver of vehicle A loses control of the vehicle.	The vehicle crashes into: _ another vehicle B; _ an obstacle.	***4;***

Gruppo 3: accidents due to lane change manoeuvres						
3-01	A	_ A vehicle A is in motion. _ A vehicle B, has halted at the side of the road and is about to reverse.	The driver of vehicle B: _ fails to notice that vehicle A is approaching; _ does not evaluate correctly the position of vehicle A.	The driver of vehicle B initiates the reverse manoeuvre.	Vehicle A crashes into: _ vehicle B; _ an obstacle; _ more than on vehicle/obstacle.	***41;***
3-02	A	_ A bus B has stopped on the right side of the road to allow passengers to get on and off. _ A vehicle A approaches in the same direction and initiates the manoeuvre to overtake the bus. _ Often in a built-up area.	The driver of the bus: _ fails to notice that vehicle A is approaching; _ does not evaluate correctly the position of vehicle A.	The driver of the bus move off again.	A vehicle crashes into another vehicle.	**--**
3-03	A	_ Driver, generally inexpert or elderly, is driving a two-wheeled vehicle A. _ A vehicle B is travelling in the same direction as A. _ A vehicle C has pulled up by the side of the road and is occupying part of the road. _ Often in a built up context.	The driver of vehicle B fails to notice that vehicle A has moved out to overtake vehicle C.	_ No reaction on the part of the two drivers. The driver of vehicle B reacts late.	The vehicle B crashes into vehicle A.	**--**
3-04	A	_ A vehicle A has stopped near a pedestrian crossing to allow pedestrians to cross. _ A vehicle B is travelling in the same direction. _ A pedestrian/s are about to cross. _ Often in a context of human settlement.	The driver of vehicle B fails to notice that: _ the pedestrians are crossing; _ vehicle A is about to move off.	The driver of vehicle B begins to overtake vehicle A.	Vehicle B crashes into: _ one or more pedestrians; _ vehicle A.	***B;***
3-05	A	_ Driver, generally inexpert or elderly, is driving a two-wheeled vehicle B, or a pedestrian/s are on the right side of the road. _ A vehicle A approaches from behind in the same direction.	The driver of B swerves abruptly towards the middle of the road.	The driver of vehicle A: _ does not react; _ reacts late.	Vehicle A runs into the two-wheeled vehicle.	***Iva – 16a;***
3-06	B	_ A vehicle B in motion halts in the lane in which it is travelling because it has gone past the road or access into which it intended to turn. _ A vehicle A travelling in the same direction is aware of the manoeuvre of vehicle A.	The driver of vehicle B: _ is not aware of the presence of vehicle A; _ does not evaluate correctly the position of vehicle A.	The vehicle B initiates reverse manoeuvre.	The vehicle B crashes into vehicle A.	**--**

Group 4: accidents occurring near entrances or at grade intersections						
4-01	A	_ A vehicle A is travelling on a road with right of way. _ A vehicle B is waiting to effect a manoeuvre from a secondary road or from an entrance. _ Often in a built-up area.	Vehicle B goes beyond the stop- line.	The driver of vehicle A: _ fails to notice the obstacle; _ notices the obstacle late.	Vehicle A crashes into: _ vehicle B; _ another vehicle; _ an obstacle; _ more than one vehicle/obstacle.	--
4-02	Both	_ A vehicle A is travelling on a road with right of way. _ A vehicle B reaches the stop line and has to turn left or right. _ Often in a built-up area.	The driver of vehicle B: _ fails to notice that vehicle A is approaching; _ does not evaluate correctly the position of vehicle A.	Driver of vehicle B: _ executes the turning manoeuvre; _ interrupts late the turning manoeuvre initiated. Driver of vehicle A: _ does not react; _ attempts an emergency manoeuvre	Vehicle A crashes into: _ vehicle B; _ another vehicle; _ an obstacle; _ more than one vehicle/obstacle.	***Q; 29; 32; 38***
4-03	A	_ A vehicle A is travelling on a road with right of way. _ A vehicle B reaches the stop line and has to cross the road with right of way. _ Often in a built-up area.	The driver of vehicle B: _ fails to notice that vehicle A is approaching; _ does not evaluate correctly the position of vehicle A.	Driver of vehicle B: _ executes the crossing manoeuvre; _ interrupts late the crossing manoeuvre initiated. Driver of vehicle A: _ does not react; _ attempts an emergency manoeuvre.	The vehicle A crashes into: _ vehicle B; _ another vehicle; _ an obstacle; _ more than one vehicle/obstacle .	--
4-04	A	_ A vehicle A is in traffic queue near an intersection and has to effect a turning manoeuvre. _ A vehicle B, often heavy, is behind and has to effect the same manoeuvre as vehicle A; vehicle B is next to vehicle A near the Stop line on the side opposite to that of the turn. _ Branch without right of way of an at grade intersection.	The driver of vehicle B anticipates the turning manoeuvre with respect to vehicle A.	The driver of vehicle A in turn initiates the turning manoeuvre.	One vehicle crashes into the other vehicle.	--
4-05	A	_ A two-wheeled vehicle A overtakes a queue of vehicles either stationary or travelling at a very reduced speed. _ A vehicle B has to turn into the road from a side access. _ Often in a context of human settlement.	The driver of vehicle B: _ fails to notice that vehicle A is approaching; _ does not evaluate correctly the position of vehicle A.	Driver of vehicle B: _ effects the crossing manoeuvre; _ interrupts late the crossing manoeuvre. Driver of vehicle A: _ does not react; _ attempts an emergency manoeuvre.	_ One vehicle crashes into the other vehicle. _ Vehicle A crashes into another vehicle C. _ Multiple collision.	***D;***
4-06	A	_ A vehicle A reaches an intersection on a road without right of way. _ A vehicle B has stopped on the road with right of way waiting to effect the manoeuvre to turn left into the same secondary road. _ Frequent conditions of heavy traffic.	The driver of vehicle B executes the manoeuvre incorrectly and invades the lane intended for vehicles of the secondary road approaching the 'intersection.	Driver of vehicle B: _ fails to notice the presence of vehicle A; _ notices late of the presence of vehicle A.	Vehicle B crashes into vehicle A.	--
4-07	A	_ A vehicle A is in motion. _ A vehicle B is travelling in the same direction and has to effect lane change. _ Approach road sections composed of groups of lanes.	The driver of vehicle B: _ fails to notice the presence of vehicle A; _ does not evaluate correctly the position of vehicle A.	The driver of vehicle B initiates the lane change manoeuvre.	One vehicle crashes into the other vehicle.	***35;***
4-08	Both	_ A vehicle A has stopped on road with right of way waiting to effect the manoeuvre to turn left. _ A vehicle B is travelling in the opposite direction and begins the manoeuvre to turn right from the road with right of way. _ Often intersection with dividing islands.	The driver of vehicle B changes manoeuvre continuing straight on.	Driver of vehicle A initiates the manoeuvre to turn left. Driver of vehicle B: _ does not react; _ attempts an emergency manoeuvre.	Vehicle A crashes into vehicle B. Vehicle B crashes into obstacle.	--

4-09	Both	_ A vehicle A is travelling on a road with right of way. _ A vehicle B, often a bus or heavy vehicle, has stopped on the road with right of way waiting to effect the manoeuvre to turn left. _ Often in conditions of heavy traffic.	The driver of vehicle B (sometimes because dazzled by the sun): _ fails to notice that vehicle A is approaching; _ does not evaluate correctly the position of vehicle A.	The driver of vehicle B initiates manoeuvre to turn left. The driver of vehicle B: _ does not react; _ attempts an emergency manoeuvre.	Vehicle A runs into vehicle B. Vehicle B crashes into: _ another vehicle C; _ an obstacle.	***H – 23; P;***
4-10	A	_ A vehicle A, often a bus or heavy vehicle, has stopped on a road with right of way waiting to effect the manoeuvre to turn left. _ A vehicle B has stopped on the road without right of way. _ Often in a built-up area. _ Often intersection with little room for manoeuvre.	The driver of vehicle A: _ fails to notice that vehicle B has crossed the Stop line; _ does not evaluate correctly the position of vehicle B.	The driver of vehicle A effects the manoeuvre to turn left turning to sharply.	Vehicle A crashes into vehicle B.	***M;***
4-11	A	_ A two-wheeled vehicle A is moving on the right side of the road. _ A vehicle B travelling in the same direction has to turn right.	The driver of vehicle B: _ fails to notice the presence of vehicle A; _ does not evaluate correctly the position of vehicle A.	The driver of vehicle B initiates the manoeuvre to turn right. The driver of vehicle A: _ does not react; _ attempts an emergency manoeuvre.	A vehicle crashes into the two-wheeled vehicle. The driver of the two-wheeled vehicle falls because of loss of balance.	**--**
4-12	A	_ A vehicle A is travelling along a road without right of way. _ A vehicle B is travelling on the infrastructure with right of way and must effect a manoeuvre to turn right. _ Intersection with reduced visibility distance.	The driver of vehicle B initiates the manoeuvre failing to reduce speed appropriately.	Vehicle B crosses over into the opposite lane intended for vehicles travelling on the minor road approaching the intersection.	Vehicle B runs into vehicle A.	**--**
4-13	B	_ A vehicle A is in motion. _ A vehicle B is travelling in the opposite direction. _ A vehicle C is waiting to effect the manoeuvre to turn into major road. _ Near an at grade intersection or lay.	The driver of vehicle C crosses over the stop line.	Vehicle B crosses over into the lane of vehicle A. The driver of vehicle A: _ does not react; _ attempts an emergency manoeuvre.	Vehicle B crashes into vehicle A. Vehicle A crashes into: _ vehicle C or other vehicles; _ an obstacle; _ more than one vehicle/obstacle.	***30;***

Group 5: accident occurring near intersections with traffic lights						
5-01	A	_ A vehicle A, with traffic lights green, has to effect the crossing manoeuvre. _ A vehicle B, often two-wheeled, is travelling in the opposite direction and has to turn left.	The driver of vehicle B: _ fails to notice the presence of vehicle A; _ does not evaluate correctly the position of vehicle A.	The driver of vehicle B initiates the manoeuvre to turn left. The driver of vehicle A: _ does not react; _ attempts an emergency manoeuvre.	One vehicle crashes into the other vehicle.	**--**
5-02	A	_ A vehicle A, with traffic lights green. _ A vehicle B is travelling on a branch of the road with the traffic light red.	The driver of vehicle B fails to notice that the traffic light is red.	The driver of vehicle B moves onto the 'intersection. The driver of vehicle A: _ does not react; _ attempts an emergency manoeuvre.	One vehicle crashes into the other vehicle.	***E – 21;***
5-03	A	_A vehicle B is in motion and reaches the intersection with traffic light green while one or more vehicles in front have begun to move. _ A vehicle A, travelling in the opposite direction, has stopped waiting to effect the manoeuvre to turn left.	The driver of vehicle B: _ fails to notice the presence of vehicle A; _ does not evaluate correctly the position of vehicle A.	The driver of vehicle B initiates the manoeuvre to overtake vehicle/s in front.	Vehicle B runs into vehicle A.	**--**
5-04	A	_ A vehicle A is in motion and reaches the intersection with the traffic light on yellow. _ A vehicle B is travelling in the same direction.	The driver of vehicle B fails to notice that the vehicle in front is coming to a halt.	The driver of vehicle B: _ does not react; _ reacts late.	Vehicle B crashes into vehicle A.	**--**

Group 8: Rear end accidents						
8-01	Both	_ A vehicle A is in motion and is forced to slow down. _ A vehicle B is travelling in the same direction. _ Heavy traffic, often in "stop and go" conditions.	The driver of vehicle B behind, often two-wheeled, lowers level of attention even when: _ he/she is travelling at a high speed; _ he/she is close behind.	The driver of vehicle B: _ does not react; _ reacts late.	Vehicle B crashes into: _ vehicle A; _ involves one vehicle; _ more than one vehicle.	***18;***
8-02	Both	_ A vehicle A is in motion and is forced to stop, often to turn left. _ A vehicle B is travelling in the same direction. _ Heavy traffic with forming of queues. _ Possible special atmospheric conditions.	The driver of a vehicle B approaching in the same direction notices the obstacle late.	The driver of vehicle B: _ does not react; _ reacts late; _ moves out.	Vehicle B crashes into: _ vehicle A; _ another vehicle C travelling in the opposite lane in the opposite direction; _ an obstacle; _ more than one vehicle/obstacle.	***O;***
8-03	Both	_ A vehicle A is in motion and is coming to a halt or is reducing its own speed. _ A vehicle B is travelling in the same direction. _ Often near to an at grade intersection or a lay-by.	The driver of vehicle B focuses attention on secondary information.	The driver of vehicle B: _ does not react; _ reacts late.	Vehicle B crashes into: _ vehicle A; _ another vehicle; _ an obstacle; _ more than one vehicle/obstacle.	***9;***
8-04	Both	_ A vehicle A in motion is about to turn, and is slowing down. _ A vehicle B is travelling in the same direction. _ Often near to an at grade intersection or a lay-by.	The driver of vehicle B is travelling at a high speed.	The driver of vehicle B: _ does not react; _ reacts late.	Vehicle B crashes into: _ vehicle A, possibly involving other vehicles; _ more than one vehicle/obstacle.	***I;***
8-05	A	_A vehicle A is in front of vehicle B in a queue and vehicle A moves off again; l vehicle B moves off simultaneously. _ Heavy traffic "stop and go" conditions.	Vehicle A is forced to stop again abruptly.	The driver of vehicle B: _ does not react; _ reacts late.	Vehicle B crashes into vehicle A.	***20;***
8-06	B	_ A vehicle A is in motion. _ A vehicle B is travelling in the same direction. _ Often in special atmospheric conditions and/or of visibility. _ Heavy traffic conditions.	The driver of vehicle A effects a significant reduction in speed, often: _ to try to correct a wrong manoeuvre; _ to avoid a sudden obstacle; _ to avoid an animal.	The driver of vehicle B: _ does not react; _ reacts late (in relation to the distance kept by the vehicle in front).	Vehicle B crashes into vehicle A.	

Group 9: accident linked to parking manoeuvres.						
9-01	Both	_ A vehicle B at the side of the road, parallel to the axis and has to turn into the road. _ A pedestrian or a vehicle A (two-wheeled or of another kind) are moving along the road. _ Often near to a built-up area or near to areas of human settlement.	The driver of vehicle B: _ fails to notice the presence of the pedestrian or vehicle A; _ does not evaluate correctly the position of the pedestrian or of vehicle A.	Vehicle B initiates the manoeuvre to turn into the road. The pedestrian or vehicle A: _ does not react; _ reacts late.	Vehicle B crashes into: _ the pedestrian; _ vehicle A. If A is a two-wheeled vehicle, the driver falls because of loss of balance.	*--*
9-02	A	_ A vehicle B has stopped on the side of the road, not parallel to the axis of the road and has to turn into the road. _ A pedestrian or a vehicle A (two-wheeled or of another kind) are moving along the road. _ Often near a built-up areas or near to areas of human settlement.	The driver of vehicle B: _ fails to notice the presence of the pedestrian vehicle A; _ does not evaluate correctly the position of the pedestrian or vehicle A.	The driver of vehicle B initiates the manoeuvre to come out of the lay-by in reverse. The pedestrian or vehicle A: _ does not react; _ reacts late.	Vehicle B crashes into: _ the pedestrian; _ vehicle A. If A is two-wheeled vehicle, the driver falls because of loss of balance.	***V – 17; N;***

9-03	A	_ A vehicle B, often heavy, is in motion has to pull up on the right side of the road. _ A vehicle A or an obstacle are on the side of the road.	The driver of vehicle B does not evaluate correctly the position: _ of the stationary vehicle A; _ of the obstacle.	The driver of vehicle B initiates the manoeuvre to pull over.	Vehicle B crashes into: _ vehicle A; _ the obstacle.	--
9-04	Both	_ A vehicle A is in motion. _ A vehicle B has stopped on the side of the road. _ Often with heavy traffic.	The driver of vehicle B: _ fails to notice that vehicle A is approaching; _ does not evaluate correctly the position of vehicle A.	The driver of vehicle B opens the door of the vehicle.	Vehicle A crashes into vehicle B.	***31;***
9-05	Both	_ A vehicle A is in motion. _ A vehicle B has pulled up on the side of the road and occupies part of the road. _ Stretch of road near built-up area or areas of human settlement.	The driver of vehicle A fails to notice the presence of vehicle B.	The driver of vehicle A: _ does not react; _ reacts late.	Vehicle A crashes into: _ vehicle B; _ an obstacle; _ another vehicle; _ more than one obstacle/vehicle.	--
9-06	B	_ A vehicle A is in motion. _ A vehicle B has pulled up on the side of the road and occupies part of the road. _ A vehicle C is travelling in the opposite direction. _ Stretch of road near a built-up area or areas of human settlement.	The driver of vehicle A: _ fails to notice that vehicle C is approaching; _ does not evaluate correctly the position of vehicle C.	Vehicle A crosses over into the lane intended for vehicle C. The driver of vehicle C: _ does not react; _ reacts late.	Vehicle A crashes into vehicle C.	***30;***

Group 10: accidents involving pedestrians.

10-01	A	_ A pedestrian, often young or elderly, in general "protected" pedestrian crossing or by traffic lights, begins to cross the road with right of way. _ Generally near to an intersection. _ Stretch of road near built-up area or areas of human settlement.	The driver of a vehicle A fails to notice the presence of a pedestrian.	The driver of vehicle A: _ does not react; _ reacts late.	The vehicle runs into the pedestrian.	***II - 13;***
10-02	A	_ A pedestrian often young or elderly, in general "protected" by a pedestrian crossing or traffic lights, begins to cross a road without right of way. _ A vehicle A in motion on the road with right of way has to turn right. _ Near an intersection. _ Stretch of road near built-up area or areas of human settlement.	The driver vehicle A fails to notice the presence of the pedestrian.	The driver of vehicle A: _ does not react; _ reacts late.	The vehicle runs into the pedestrian.	***A;***
10-03	A	_ A pedestrian or a two-wheeled vehicle are in motion at the side of the road. _ often in the opposite direction to that provided for. _ A vehicle A is travelling in the lane, and often has to move towards the right shoulder of the road.	The driver of vehicle A fails to notice the presence: _ of the pedestrian; _ of the two-wheeled vehicle.	The driver of vehicle A: _ does not react; _ reacts late.	The vehicle runs into: _ the pedestrian; _ the two-wheeled vehicle.	***Ivb - 16b;***
10-04	A	_ A pedestrian is about to cross the road. _ A vehicle A is in motion. _ In general there is no pedestrian crossing. _ Often in particular atmospheric conditions.	The pedestrian: _ fails to notice that vehicle A is approaching; _ does not evaluate correctly the position of vehicle A.	The pedestrian begins to cross the road.	The vehicle runs into the pedestrian.	***Ia - 12a;***
10-05	B	_ A vehicle A prepares to turn left into a one-way road. _A pedestrian or a two-wheeled vehicle is travelling on the road in the opposite direction to that allowed.	The driver of vehicle A: _ fails to notice the presence of the pedestrian or the two-wheeled vehicle; _ does not evaluate correctly the position of the pedestrian of the two-wheeled vehicle.	The driver of vehicle A initiates the turning manoeuvre.	The vehicle runs into: _ the pedestrian; _ the two-wheeled vehicle.	--

Group 11: other typology not referable to any of the preceding ones.						
11-01	A	_ A vehicle A is in motion. _ Infrastructure characterized by the presence of rows of trees on both sides. _ Particular atmospheric conditions (strong wind).	A branch or something else detaches itself from one of the trees.	The driver of vehicle A: _ tries to avoid the impact; _ does not react.	The object bumps against the vehicle. Vehicle A swerves and crashes into: _ another vehicle; _ an obstacle; _ more than one vehicle/obstacle.	--
11-02	B	_ A vehicle A is in motion. _ Stretch of road near bend.	An animal suddenly crosses the road.	The driver attempts a manoeuvre and loses control of the vehicle.	Vehicle A: _ leaves the road and crashes into an obstacle; _ crashes into another vehicle; _ crashes into more than one obstacle/vehicle.	--
11-03	B	_ A vehicle A is in motion prepares to effect the manoeuvre to overtake. _ A vehicle, often heavy, in front is travelling in the same direction.	One or more animals begins to cross the road, often suddenly.	The driver of vehicle B moves out while vehicle A is overtaking. The driver of vehicle A: _ does not react; _ reacts late.	Vehicle A: _ leaves the road and crashes into an obstacle; _ crashes into another vehicle; _ crashes into more than one obstacle/vehicle.	--
11-04	B	A vehicle A, often heavy, is travelling on the infrastructure.	The vehicle undergoes a failure.	The driver does not have time to react.	Vehicle A: _ leaves the road crashes into an obstacle; _ crashes into another vehicle; _crashes into more than one obstacle/vehicle.	***10;***
11-05	B	A vehicle A, often two-wheeled, is in motion.	The driver fails to notice the presence road surface: _ of a hole; _ of a large bump.	The driver of vehicle A: _ does not react; _ reacts late.	Vehicle A: _ crashes into another vehicle; _ crashes into an obstacle; _ under goes mechanical damage.	--