INTRODUCTION

Recent statistical reports on urban accidents highlighted a worrying increase in both the number of accidents and the severity of their consequences.

The high social and economic costs imposed on the community by this serious problem must draw the attention of experts to try to solve it.

In this paper we briefly describe the architecture of a decision support system based on a set of mathematical models that has the objective to help the planner to determine those interventions to be implemented on the network in order to reduce the number and or the severity of the accidents occurring on road urban networks. The tools which allows to integrate the models is the GIS technology. In our work we use a set of "accident models" as a performance function in order to simulate the effect of the accident countermeasures on the network (see Maher and Summersgill, 1996; Maycock and Hall, 1984). To this purpose, we employ an assignment model to simulate the traffic condition on the network. The output of the assignment model becomes input data for the accident models that allow to estimate the accident risk for each network location and then for each network scenario.

The methodology is constituted of three phases and a preliminary one. The preliminary phase concerns with the identification of those network locations to be subject to countermeasures. In the first phases the set of mathematical models is built in order to determine the factors that affect accident rates for each black-spot. Once a set of countermeasures is defined, in the second phase they are simulated by means of the accident models and of a traffic assignment model. We obtain a set of countermeasures and the consequent network scenarios. In the third phase all the scenarios are analysed and compared in order to choose what safety project should be implemented.

METODOLOGY

Preliminary phase: Black-spots analysis
The first step to face the problem of traffic safety is to analyse the current situation with respect to the black-spots of the road network that are the set of locations to be corrected with some intervention.

In our opinion, to label a network site as black-spots, we have to consider not only the rate of accidents occurred during the considered time period but some criteria (or weights) should be taken into account. For example, we should consider the accident rate with respect to the severity of the accidents, the traffic volume at the time of the accident. This problem is important in the urban areas where we observe a lot of accident with minor consequences.

To this purpose, great efforts have to be made in the integration of the data with reference to:

1) accident data collecting operations;
2) accident data integration

This is an important issue of safety studies since different actors (state police, municipality guards, etc.) could be involved when accidents occurs with different approach to that events (see Broughton, 1996).

This problem have to be carried out by using GIS technology that is a valid tools to gather and represent different kind of data with a geographical, interactive and easy to read way.

**First phase: accident models**

For each location we have to specify an accident simulation model. In this field great effort had been made at the TRL where accident models had been specified and calibrated for different layouts of roads elements (junctions, links, roundabouts, etc.) and with different levels of details by considering both geometrical and traffic attributes.

Our work has been addressed to the TRL approach assuming, for the i-th black spots, the number of accidents occurred distributed as a Poisson random variable in the time unit (or space unit), while we assume the expected number of accident distributed as a Gamma random variable (Maher et al., 1996).

Let us assume as Poisson-distributed the number of accidents \( y_j \) counted on the network element \( j \) during the period \( t \), i.e.:

\[
p[y_j] = \frac{\mu_j^{y_j} \exp(-\mu_j)}{y_j!}
\]

where:

- \( \mu_j = \lambda_j T \) if the element \( j \) is a road section or intersection;
- \( \mu_j = \lambda_j (L_j T_j) \) if \( j \) is a road link, then \( L_j \) is the length of the road link.
- \( \lambda_j \) is the expected number of accidents per unit of time and \( T \) is the time interval considered
To model the variable $\lambda_j$ we assume the following functional form that always ensures non-negative values for the accidents number:

$$
\lambda_j = \exp(\beta_j^T X_j) = \exp(\beta_1X_1 + \beta_2X_2 + \ldots + \beta_mX_m) \quad j=1,2,\ldots,N \quad (2)
$$

where:

- $\beta_j$ is a vector of model parameters to be estimated;
- $X_j$ is a vector of attributes considered in model specification (explanatory variables vector) for the site $j$;

As shown in the eq. 2 the log-function of the expected number of accident is a linear function of the parameters vector $\beta$.

Thus, let $\lambda_j$ be the expected number of accidents occurring per unit of time and assume it as variable representing the accident risk on the network element $j$.

According to this approach, accident models could be considered as network performance functions which provide the variation of the network safety level as function of network and traffic attributes.

The specification of the attributes vector $X$ significantly depends on the available or collected data during the surveys.

In general, specifications presented in consider attributes concerning traffic, site geometrical layout and environmental conditions literature (Amis, 1996; Fridstrøm, 1995; Miaou, 1994).

Most of the attributes considered in the accident models are assumed also in the formulation of the road network supply model.

Once the mode has been formulated has to be calibrated (estimation of the parameters vector $\beta$).

The results of the accident models calibration will provide indications on the possible relationship between accident numbers, attributes and their influence in accidents occurrence likelihood and than the expert could propose a set of safety measure to reduce the actual accident level.

**Second phase: Simulation of the countermeasures**

To simulate the effect of the countermeasures defined in the first phase a traffic assignment model have to be adopted. In particular, given the Origin-Destination travel demand matrix we can simulate the link traffic flows (that are, link by link, an attribute of the accident models) by means of a SUE assignment model (Stochastic User Equilibrium).
In this case each intervention on the road network can be modelled through the network supply model (graph and link cost function) modifying the attributes. Great attention have to be paid to the modelling of the junction in order to fit the attributes assumed in the accident models. The link flow obtained by the updated assignment (supply) model and the update network attributes are employed as input data in the accident models which allow to estimate the safety improvements (or not) given by the simulated network configuration (countermeasures).

This phase can be reiterated by considering a set of scenarios (possible network configurations).

All the simulated network scenarios have to be analysed in the next step in order to choose the countermeasure to be implemented.

**Third phase: analysis of the simulated scenarios**

In this phase the analyst have to consider the results obtained by the simulation of the phase. The evaluation of the considered alternatives can lead to the choice of the safety countermeasure or to the necessity of propose new project if the accident level is still higher than a given threshold. In the last case the procedure have to be reiterated starting from the first phase by assuming different network scenarios. Actually, we have considered only a safety based criteria, but it is possible to extend the problem to a multiobjective problem considering additional criteria in order to take in to account also network performance measures (Ottomanelli et. al., 2001).

**CONCLUSION**

In order to reduce the increasing number of accidents occurring in urban areas in this paper we shortly described a methodology that allows, by integrating accident and traffic models, to planning road safety in a simulation environment and so to propose accident countermeasures by estimating a prior their consequence (reduction or increasing) in term of accident level. The proposed DSS has been used only on test network in order to check the robustness of the whole framework. The study is now addressed to real sized networks.

**REFERENCES**


