With over 8,100 traffic fatalities in 1997 and an accident rate per 100 million vehicle kilometres travelled, approximately five times that of United States, Argentinean road authorities are now beginning to focus attention on traffic safety and driver education. One of the main problems in the search of causes for car accidents in Argentina is the lack of a reliable and updated data base. The results and conclusions presented in this paper are based on a thorough analysis of car accidents in the Province of San Juan, Argentina. A seven-year data base of car accidents has been compiled from police reports, including the results of traffic counts at intersections and other collision locations. In addition, topographic and filmed reports of such places and their surroundings bring about parameters such as stop lines, visibility triangles, road size, traffic light performance, etc., which allow to carrying out of a traffic flow analysis for proposing measures aiming to minimize accidents. For San Juan province, in general, the main causes are: high absolute car speeds, speed differences between vehicles, lack of good lighting, poor driving habits, lack of traffic control devices such as signs, signals, and an absence of road markings.

Key Words: Traffic, Safety, Accidents, Driver education
1.2 Research in traffic safety in the national context

Argentina has long overlooked the need to take counter measures based on traffic safety research aiming at improving road safety. With approximately five to six times the traffic fatalities per 100 million vehicle kilometres than that of the United States, Argentinean authorities are beginning to grow conscious of the problem and to pay due attention to traffic safety. One of the main problems concerning traffic accident research in Argentina is the lack of a reliable data base. Private organizations such as the Association “Luchemos por la Vida”\(^1\) (Let’s fight for Life), the “Instituto de Seguridad y Educación Vial”\(^2\) (Institute for Road Safety and Driver Education), and some official entities such as the “Registro Nacional de Antecedentes de Tránsito”\(^3\) (National Register of Traffic Information) are undertaking a global data collection and its statistical analysis. By 1997, the Association Let’s fight for Life, has reported for Argentina 8,123 traffic fatalities and more than 120,000 injured people of various levels of seriousness. A significant finding was that 31% of the drivers involved were between 20 and 40 years old\(^3\).

2.1 Characteristics of traffic flow in San Juan province

The Province de San Juan is one of the 23 provinces of Argentina. It has 564,900 inhabitants in area of 89,650 km\(^2\), 122,930 registered motor vehicles, 40,250 motorcycles, and 145,000 bicycles\(^4\). San Juan, the provincial capital has in the central area, a one-way grid road system with a block length of 100 metres. Currently there are 138 signalised intersections, and 4,124 unsignalized intersections\(^5\) (also without any traffic control devices). Speed limits are not posted, but according to legislation it is 40 km/h on city streets and 60 km/h for two-way avenues outside the downtown area. On the ring road encircling the city and access highways, the speed limits are 80 km/h maximum and 50 km/h minimum. The city ring road is four-lane divided highway. City outskirts and rural areas in the province feature 1,428 km of paved roads, 2,330 km of consolidated roads, and 1,470 km of dirt roads\(^6\) (without any type of maintenance). Roads within the National Highway System included 735 km paved and 94 km unpaved roads\(^7\) in the Province of San Juan.

The city of San Juan is endowed with a mediterranean climate that in many aspects favours the use of bicycles and motorcycles during most of the year. It is a high-density city, with land-use mostly residential and commercial. City blocks are short, with a grid layout and with almost imperceptible street slopes, thus making it an ideal environment for bicycles, pedestrians and motorcycles. Downtown, bicycles and motorcycles have parking zones close to street corners, separated from car parking areas. During peak hours, the cyclists are men mainly. Women prefer public transit, walking, or motorcycles. Most of the bicycle movement during peak hours is to or from low-income neighbouring areas, whose dwellers have a low motor vehicle ownership. There are four peak-hour periods: 7 to 9 AM; 11:30 AM to 1:30 PM; 5 PM to 7 PM and 8 PM to 9:30 PM. The four peak periods reflect the daily travelling pattern according to work and school schedules. Normally, workers go back home in the afternoon. Traffic census in the main streets shows that bicycles account for 15\% to 20\% of the total vehicles at peak hours. In a census of the city main avenue (in east-west direction), a volume of 250 bicycles/hour was recorded at noon rush hour. Outside the AM and PM periods, bicycles from the outskirts also flow in and out of the downtown area for leisure or shopping trips. At present, the trend shows that the popularity of bicycle riding is slowly decreasing with an increase in the use of small motorcycles.

2.2 Traffic accidents data base

A data base about traffic accidents was developed by the research team on road and driving safety of EICAM\(^8\) for the period 1989-1997. Data forms were provided by the provincial Police Department. The form is updated according to the information requested by the new form designed by the Sistema Nacional de Antecedentes de Tránsito – SINAT\(^9\) (National System for Traffic Data), incorporating new data not regarded by the provincial form so far. The data base provides the provincial organization for road and driving safety, an informatic system where new data can be readily and directly input. The task of updating, verifying and coding of the city and outskirts streets was done at an early stage, prior to the design of the data base. This allows to add or modify data in the street pattern of San Juan city.

It has a practical menu for loading and modifying data of accidents referred, in this case, to motorcars. In a similar way it is possible to bring in menus to load/modify data on the individuals and conditions at the time of the
accident. The data base thus created will be used with a geographical information system for graphically locating and measuring the black spots, the locations of frequent car accidents. This procedure will allow the Police Department to input reliable data and use them in keeping a steady tracking of, for example, black spots.

2.3 Traffic accidents in San Juan province

In the province of San Juan, the events produced as a consequence of the traffic are classified as:
• **Accident**: those involving minor and serious injuries and fatalities.
• **Collisions**: Those damaging only property.
• **Crash**: Generic term for accidents and collisions.

The data obtained during the four last years, 1994, 1995, 1996 and 1997, allow to establish, as a starting point, the scope of the situation of traffic accidents and the trends. Table 3 shows for San Juan and Argentina the more common indexes that measure the seriousness of accidents. It is important to point out that by comparison with Argentina, San Juan shows a relationship injured-fatalities/inhabitant that places it over the average in the number of vehicles involved in traffic accidents.

Figure 1 shows for San Juan province the number of traffic accidents by category. While injury accidents have increased, serious injury and fatalities have decreased.

Figure 2 presents the monthly variation of traffic accidents. It is possible to observe that the changes are not meaningful, though a slight increase can be appreciated in March-April and September-October. The values corresponding to November-December 1997 are lower than the same period of 1996. The distribution of accidents per zone is shown in Figure 3.

On Saturdays, Sundays and holidays, the index is higher than on weekdays as shown in Figure 4.

In order to compare the results, the number of accidents has been given an annual average daily value, both on weekdays and on Saturdays and holidays. Figure 4 shows that the number of accidents on Saturdays, Sundays and feast days are 27% higher than on working

Table 3 Indexes and comparative values between San Juan and Argentina

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>San Juan</td>
<td>Argentina</td>
<td>San Juan</td>
<td>Argentina</td>
<td>San Juan</td>
</tr>
<tr>
<td>Injured / day</td>
<td>4.5</td>
<td>310</td>
<td>5.1</td>
<td>328</td>
</tr>
<tr>
<td>Injured / 100,000 inhab</td>
<td>301</td>
<td>330</td>
<td>337</td>
<td>344</td>
</tr>
<tr>
<td>Injured / 1,000 veh</td>
<td>17</td>
<td>21</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>Fatalities / day</td>
<td>0.5</td>
<td>24</td>
<td>0.5</td>
<td>22</td>
</tr>
<tr>
<td>Fatalities / 100,000 inhab</td>
<td>34</td>
<td>25</td>
<td>30</td>
<td>23</td>
</tr>
<tr>
<td>Fatalities / 1,000 veh</td>
<td>1.9</td>
<td>1.6</td>
<td>1.65</td>
<td>1.4</td>
</tr>
<tr>
<td>Fatalities / Person / Year</td>
<td>527</td>
<td>632</td>
<td>606</td>
<td>741</td>
</tr>
</tbody>
</table>

Sources: Refs. 1, 4, 10
days. The effect of the difference of visibility during the day or at night on the occurrence of traffic accidents is shown in Figure 5\textsuperscript{10}. Accidents taking place during day light are slightly increased with respect to those occurring at night, however traffic volumes are much lower at night.

Figure 6\textsuperscript{10} shows the participation rate according to gender and its annual variation. In spite of the women/men drivers participation varying from 1994 to 1997, the rate of driving licenses issued to women in the province was 35% over a total of 186,000 by 1997. The census carried out at peak-hours at most-probable accident-occurring places showed that participation of the women accounted for 11 to 20% depending on the peak hour considered. Assuming 35% of driving license holders are women and 65% men, an index has been determined for representing the number of accidents according to gender per 100 driving licences. In the Province of San Juan, a governmental office issues the driving licences.

Figure 7\textsuperscript{10} shows the distribution of accident participants, including both causes and victims, for the 1994-1997 period. Light vehicles, bicycles, motorcycles and pedestrians have a larger share in accident occurrence with injured participants compared with heavier vehicles.

2.4 Fatal accidents

Among car accidents, those involving serious personal injuries and deaths obviously have the greatest impact on society. On the national scale of accident-casualties ratio, San Juan is placed twelfth among the provinces\textsuperscript{1} in terms of fatalities.
Figure 8\textsuperscript{10} shows that the annual variation of fatalities have a decrease of about 20.4\% for 1997 with respect to 1994.

Figure 9\textsuperscript{10} shows the monthly distribution of accidents fatalities for 1994-1997.

Until 1996, the periods March-April, June and December have a greater number of fatal accidents. Causes may be due to the Easter weekend, “long” weekends involving national and provincial holidays for the June period and Christmas and New Year’s Eve holidays for December. In 1997 the monthly distribution of accident fatalities was not typical but emphasizes the tendency towards a decrease of car accident fatalities.

Figure 10\textsuperscript{10} shows the hourly distribution of fatalities with greater occurrences in two well-marked periods: 6 to 8 AM and 7 to 9 PM, that is the dawn and dusk hours when natural daylight in wintertime is low. The 1997 distribution shows another peak period: Midnight to 1 AM. A possible explanation could be that at that time of the night many youngsters speed to and from entertainment and dancing places on the outskirts of San Juan city, particularity on Friday and Saturday nights.

Table 4 shows traffic fatalities by mode. The percent of pedestrians and bicycles fatalities is considerable higher than European and North American countries.

While the proportion of pedestrians fatalities for Argentina is five times that of San Juan, in the province of San Juan bicycle and motorcycle fatalities account for 48\%, which almost double that of the national figure of 28\%.

Comparing the figures of 1997 to those of 1996, there was a 23\% decrease in pedestrian fatalities; a 3 \% decrease in motorcycle riders fatalities; bicycle fatalities remained constant. The significant increase of 13\% in car

![Figure 8](image1.png)

**Fig. 8 Fatal accidents**

![Figure 9](image2.png)

**Fig. 9 Monthly variation of car accident casualties**

![Figure 10](image3.png)

**Fig. 10 Hourly distribution of fatalities**

<table>
<thead>
<tr>
<th>Year</th>
<th>Pedestrians</th>
<th>Bicycles</th>
<th>Motorcycles</th>
<th>In cars: drivers and passengers</th>
<th>Others\textsuperscript{1}</th>
<th>Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>44 %</td>
<td>13 %</td>
<td>15 %</td>
<td>27 %</td>
<td>1.00 %</td>
<td>8,123</td>
</tr>
<tr>
<td>Argentina</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Province of San Juan</td>
<td>9 %</td>
<td>24 %</td>
<td>24 %</td>
<td>43 %</td>
<td>0.00 %</td>
<td>148</td>
</tr>
<tr>
<td>1996</td>
<td>44 %</td>
<td>13 %</td>
<td>15 %</td>
<td>27 %</td>
<td>1.00 %</td>
<td>7,714</td>
</tr>
<tr>
<td>Argentina</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Province of San Juan</td>
<td>22 %</td>
<td>24 %</td>
<td>27 %</td>
<td>27 %</td>
<td>0.00 %</td>
<td>150</td>
</tr>
</tbody>
</table>

Source: Ref.\textsuperscript{10}

Table 4 Fatalities by mode
accident fatalities could be explained by a change of public transport use: taxis being preferred to bus public transportation.

Table 5 shows the evolution of car accident fatalities for the 1994-97 period with a decrease for pedestrians and bicycle riders, in coincidence with a decrease in fatalities, whereas fatalities of motorcycle riders decreased 3% with respect to the 1996 figures.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Fatalities</th>
<th>Pedestrians Fatalities</th>
<th>Pedestrians %</th>
<th>Bicycle Fatalities</th>
<th>Bicycle %</th>
<th>Pedestrian and bicycle Fatalities</th>
<th>Pedestrian and bicycle %</th>
<th>Motorbikes Fatalities</th>
<th>Motorbikes %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>186</td>
<td>37</td>
<td>20</td>
<td>41</td>
<td>22</td>
<td>78</td>
<td>42</td>
<td>34</td>
<td>18</td>
</tr>
<tr>
<td>1995</td>
<td>165</td>
<td>38</td>
<td>23</td>
<td>35</td>
<td>21</td>
<td>73</td>
<td>44</td>
<td>43</td>
<td>26</td>
</tr>
<tr>
<td>1996</td>
<td>150</td>
<td>33</td>
<td>22</td>
<td>36</td>
<td>24</td>
<td>69</td>
<td>46</td>
<td>41</td>
<td>27</td>
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<tr>
<td>1997</td>
<td>148</td>
<td>13</td>
<td>9</td>
<td>36</td>
<td>24</td>
<td>49</td>
<td>33</td>
<td>36</td>
<td>24</td>
</tr>
</tbody>
</table>

Table 5: Traffic fatalities, pedestrians, bicycle and motorbikes (Source: Ref. 10)

Figure 11 shows the traffic mode in the City of San Juan, metered on the city ring highway, i.e. Avenida de Circunvalación, on both directions for a typical week day.

In the graph, two distinctive peaks can be seen, one for the 7 to 9 AM period, the other for the 8 to 10 PM period. These periods are concurrent as well with those corresponding to the highest number of accident fatalities involving bicycles and motorbikes.

Figure 12 shows a map of the City of San Juan and its outskirts, featuring the places where four or more accidents occurred for the period considered. The graph shows the ring highway Av. Circunvalación, where the statistical study was done. The physical features of the black spots, clearly show east-west and north-south accident corridors, with higher occurrences at crossings with Av. Circunvalación. In 1997 Tucumán Street appeared as a new north-south accident corridor.

4.1 Present law and regulations in force
The province of San Juan adopted the N° 24449 Traffic National Law on December 21, 1995, through the N° 6684 Provincial Law. In order to thoroughly enforce the national law and taking into account the seriousness and magnitude of car accidents in the Province, new law initiatives have been proposed thereafter.

The Agreement Decree N° 71 on 07/10/96 brought about the “Provincial Council of Road Safety”, an organization intended for planning and coordinating the action of the various official organizations involved in Traffic and Driving Safety. The official organizations which are more closely related to driving and traffic regulations perform as permanent members, whereas other bureaus such as the Ministry of Education, Ministry of Public Health, Civil Defence, etc., participate with non-permanent members. The duties of this Council are to propose polices for accident prevention, to plan operative actions for driver and road safety, to assign duties and responsibilities for law enforcement to the various official entities and to coordinate and control the execution of safety programs and, finally, to evaluate the results.

4.2 Proposals under study
At present there is a legal project under study at the Provincial House of Representatives called “Survey on Traffic and Driving Safety” intended to evaluate and control “from outside the “Executive Power”, the results
of government actions on this matter. Control is accomplished through a permanent parliament which is responsible for road and driving safety in the province. The responsible authorities are required to evaluate statistical data, to propose mitigation measures and to account for their performance as an entity.

The law project seeks as well to get a tool for inserting the subject of road and driving safety as a central concern within the community of interests, setting, therefore, the guidelines for publishing in the media the official statistic results (this as an obligatory duty), along with the judgement that the representatives’ commission has drawn on the entity’s pressing the authorities in charge. The aim is to change social behaviour and bad driving habits which are the main cause for the majority of serious car accidents.

Since the matter at stake is a many-faceted one, the commission is multidisciplinary, thus avoiding issuing options from just one side. This commission should not overlap functions with the Provincial Council for Road and Driving Safety, for the former is the means for the community for controlling and evaluating government action, besides contributing proposals for improvement, whenever there is such a chance. This proposal was made law of the Province on December 1997, during the last session of the Province Legislature.
Although the number of motor vehicle ownership is 1.5 times lower in San Juan than the average in Argentina (in 1997), the number of fatalities per 1,000 inhabitants is about 1.2 times higher than in the entire country. These figures suggest the need of carrying out some specific research to launch a program to reduce the substantial life and property losses produced by street accidents, estimated at some $ 10 billion dollar (US$) per year throughout the country. Such research calls for reliable and updated databases which were designed according to the SINAT forms. From the data analysis shown in the graphs and tables mentioned above, the following conclusions have been drawn.

(a) Although the number of accidents continued to increase in 1997, fatalities decreased. For example fatalities decreased 20.4% compared with 1994.

(b) During 1997, the number of accidents were 27% higher on Saturdays and on holidays than on weekdays. It has been found that the death toll increases during October, February and August. October has the highest value: 20 fatalities in a month, which is comparable with 1994. Most fatal accidents happen when the daylight is poor, i.e. at dawn and at dusk (from 6 AM to 8 AM and from 6 PM to 8 PM), and during the rush hours in the province. The period 6 AM to 7 AM has the highest rate: 25 deaths per hour.

(c) Women were involved in about 24% of the total accidents in 1997, this value is 11% lower than 1996.

(d) During this period, bicycles, motorcycles, light vehicles and pedestrians were the most affected. While accidents resulting in cyclist and motorcyclists’ deaths account for 28% of all fatalities throughout the country, such percentage reaches about 48% in San Juan.

(e) Between 1994-1997 fatal cyclist and pedestrian accidents showed a decrease. However, motorcyclist deaths increased until 1996, but 1997 showed a decrease of 3% compared with 1996.

As the probable causes or action sequences leading to accidents are not recorded by the Traffic Police, they are not included in the present database. Based on discussion with the Traffic Police and from field surveys, the following are considered the main causes of pedestrian and cyclist accidents:

(a) The high speeds at which many motor vehicles travel is considered to be one of the main causes of accidents involving pedestrians.

(b) Bicycles with poor or no lighting are also considered a primary cause of accidents. Many of the vehicles observed, lacked lights. According to surveys, most bicycles lacked both front and rear lighting. The concurrence of vehicles and bicycles without lighting, and barely illuminated and narrow streets, is also another probable cause of accidents involving cyclists.

(c) Other probable causes are: riding bicycles without helmets and bad riding habits. Cyclists often ride along the left street lane (high speed lane) because parking areas and bus stops are on the right lanes. Likewise, they often ride on the city ring highway, Av. de Circunvalación (ring road), where no animal-powered vehicle is allowed. Cyclists riding in the wrong direction on one-way streets are also common. A field survey during the rush hours (11:30 AM to 1:30 PM) on crossings having traffic lights, has shown that some 22% of the total cyclist’s recorded, perform unsafe and illegal actions (left turns or forward motion during the red phase). Bicycles account for 51% of the total unsafe and illegal actions, while cars and motorcycles for 12% and 9% respectively. Besides travelling at high speed, most drivers do not stop at crossings and they generally show little concern for pedestrians and cyclists’ safety. Besides violating traffic signs, it is usual for drivers to ignore red lights at night or in the siesta (afternoon period), a habit that may result in accidents. Another bad habit in San Juan and throughout Argentina, is that drivers usually start crossing intersections on the yellow phase, instead of waiting for the green signal. Such a practice often results in dangerous situations, since the side-street traffic speeds up in order to be able to cross before the red phase.

(d) The lack of traffic engineering in municipalities, together with poor road structure designs, are also probable causes of many accidents. By way of example, few intersections have zebra lines or any signs warning drivers that they must stop or that they may turn. Few unsignalized intersections have “STOP” or “GIVE WAY” signs. Other examples include poorly designed roundabouts, no road markings, and inadequate intersection sight distance.
The following are some suggestions tending to reduce accident frequency and seriousness in the Province of San Juan:

(a) The Provincial Police Traffic Division is considered to be an essential element in lowering the accident rate. Also, the new Traffic Law should be put into practice as soon as possible. This new law takes into account the main probable causes of traffic accidents. Police should enforce regulations regarding vehicle lighting during night hours; speed limits; respect for pedestrians’ rights, and any other rules promoting drivers, cyclists and pedestrians’ safety.

(b) A traffic education program is essential, because the present situation clearly shows that drivers ignore, or simply neglect traffic rules and regulations, due to the fact that they are not compelled to comply with them. There is a “Tribunal of Faults” in San Juan, which should punish transgressors detected by the traffic police. Generally speaking, traffic controls often include campaigns that pay attention to only a few safety regulations at a time. The police should enforce all safety rules simultaneously, as a part of a permanent prevention program. Education should begin at home and at schools; and driving licences should only be issued after passing strict tests. Old people should be re-tested periodically. Education itself, however, will not lower the accident rate if it is not concomitant with due enforcement of traffic rules.

(c) A specific education program for cyclists is also necessary. Few bicycles, if any, have lights or reflectors. A program promoting the use of lights on bicycles is essential to lower the accident rate.

(d) A long-term program providing specific tools to make traffic safe is advisable. Among the most important ones are: zebra lines, traffic controls at street crossings with no traffic lights, speed limit signs, and enhancement with roundabouts.

(e) Next, a review of the government’s responsibility regarding traffic control, is also advisable. At present there is jurisdiction overlapping, resulting in unclear situations. For instance, the police record and compile data, that are not given out to municipal or provincial offices. To reverse this situation, municipalities should seek professional advise from skilled personnel trained in traffic engineering.

(f) Finally, the law on “Traffic Safety Follow-up”, creating a multidisciplinary commission should be enforced in order to give the community a working tool for controlling and evaluation government officials actions.