XXIV WORLD ROAD CONGRESS
MEXICO 2011

SPAIN – NATIONAL REPORT

STRATEGIC MATTER C – ROAD SYSTEMS SECURITY:
"A STRATEGIC APPROACH TO SECURITY: PUTTING KNOWLEDGE INTO PRACTICE"

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SUMMARY

The important human, social and economic consequences of traffic accidents led the Spanish authorities to become more aware of the importance of road safety on the roads under their control and to start preparing policies and plans for the improvement of driving conditions on their roads. The Spanish Government has declared the improvement of road safety as one of their main priorities, taking on the EU´s commitment to reduce the number of fatal traffic accidents by half throughout 2010 with respect to 2001 and to reduce that to a quarter by 2020. With this aim in mind, a Road Safety Strategy Plan is being developed which lays out the measures to be taken in dealing with all the factors that influence road safety, particularly road infrastructure. The main areas of action with reference to road infrastructures are maintenance, improvement and construction of infrastructures, the development of audits, studies and rules in order to improve road safety and improving the use of the infrastructure and traffic management and information. This report includes all of the newest and most efficient initiatives that have been developed in Spain in recent years to improve driving safety on the National Roads Network. It details the classification of levels of road safety and of the detection of sections of road that have a high potential for improvement. It also introduces a geographic information support system for road network safety inspections, the development of automated procedures for the design of prevention measures against sun glare in critical sections of road and for the evaluation of the consistency of the road, as well as an automated system of control and management of speeding offences. The results obtained up until now are very positive, having achieved the objective of a 50% reduction of fatal accidents established by the European Union for the year 2010, a year ahead of the planned date.

1. STRATEGIC PLANNING OF ROAD SAFETY

In the year 2004, the Strategic Plan for Road Safety 2005-2008 was formulated in Spain with the aim of reducing the amount of deaths on the roads during this period, taking as a base the figures from 2003. This objective was in line with the European objective of reducing the amount of deaths by 50% in 2010 and clearly focused on improving the situation of road safety in Spain.

In order to achieve this, some specific operational objectives were programmed with a series of actions to develop during the validity period of the Plan. The Key Strategic Actions Plan is divided into ten strategic areas that are considered priorities for improving road safety and that involve an adaptation for Spain´s particular case of the outline of priorities of the European Action Programme. These areas are as follows:

1) Education and road training

2) Raising road safety awareness

3) Surveillance and control

4) Vehicle safety

5) Infrastructures and management and traffic information

6) Road and work safety on transport

7) Attention to victims and their families

8) Investigation and analysis of road safety

9) Society participation

10) Coordination between Authorities

In 2008 the proposed objective was exceeded at a national level with a 40% reduction of fatal accidents during the validity period of the Strategy Plan, having achieved a decrease of 2,300 victims compared to 2003, which is a 43% reduction.

The Road Safety Strategy Plan 2010-2020 is currently being written, which will follow on from the previous plan.

The main areas of action in terms of road infrastructures are the following:

- Maintenance, improvement and construction of infrastructures and conditioning with the aim to improve road safety
- Development of audits, studies and rules for the improvement of road safety
- Improvement of the use of infrastructure
- Improvement of traffic management and information

In terms of maintenance, improvement and construction of infrastructures, the Transport and Infrastructures Strategy Plan is valid, in which mid and long term objectives have been established in order to achieve a reduction of 50% of the number of victims of fatal traffic accidents in 2010 compared with 2002, and to a 75% reduction by 2020. In order to achieve the objectives, the General Management of Roads of the Ministry of Public Works, responsible for the management of the national network of Spanish roads, foresees the construction of more than 5,600 kilometres of high capacity roads, which means an increase of 62% when compared to the 9,000 km that were in service in 2005. Once the plan has finished, the network of high capacity roads will constitute almost 15,000 km, meaning that 94% of the population will be at least 30 km from an urban motorway and a substantial improvement is foreseen in the security of long distance journeys if the tendency observed in recent years is maintained with regards to the correlation between the number of deaths and the length of high capacity roads reflected in Figure 1.

In terms of maintenance, the annual investment has been increasing progressively to 2% of the asset value of the network. This investment does not only include the maintenance of the network, but also investment in local improvements of road safety, improvements on road crossings, reorganizing road accesses, road integration, etc., having observed a strong correlation between the investment dedicated to maintenance and the reduction in the number of fatal accidents registered in the network, as shown in Figure 2.

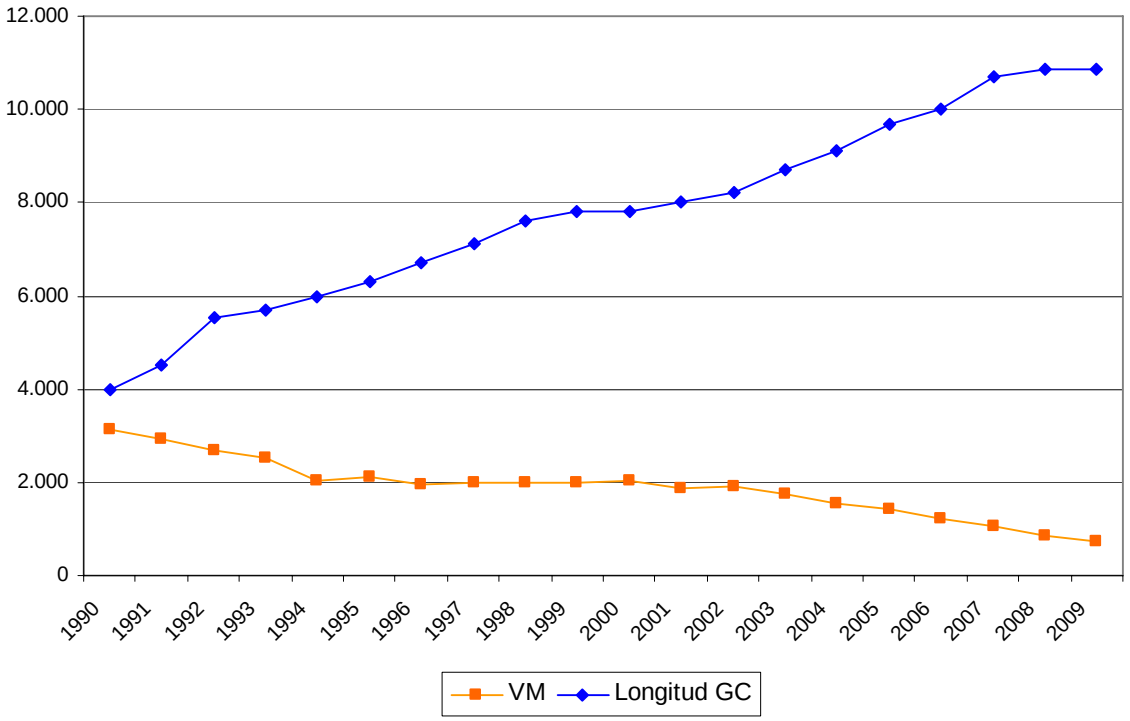

Figure 1 Correlation between length of high capacity network and reduction of road mortality

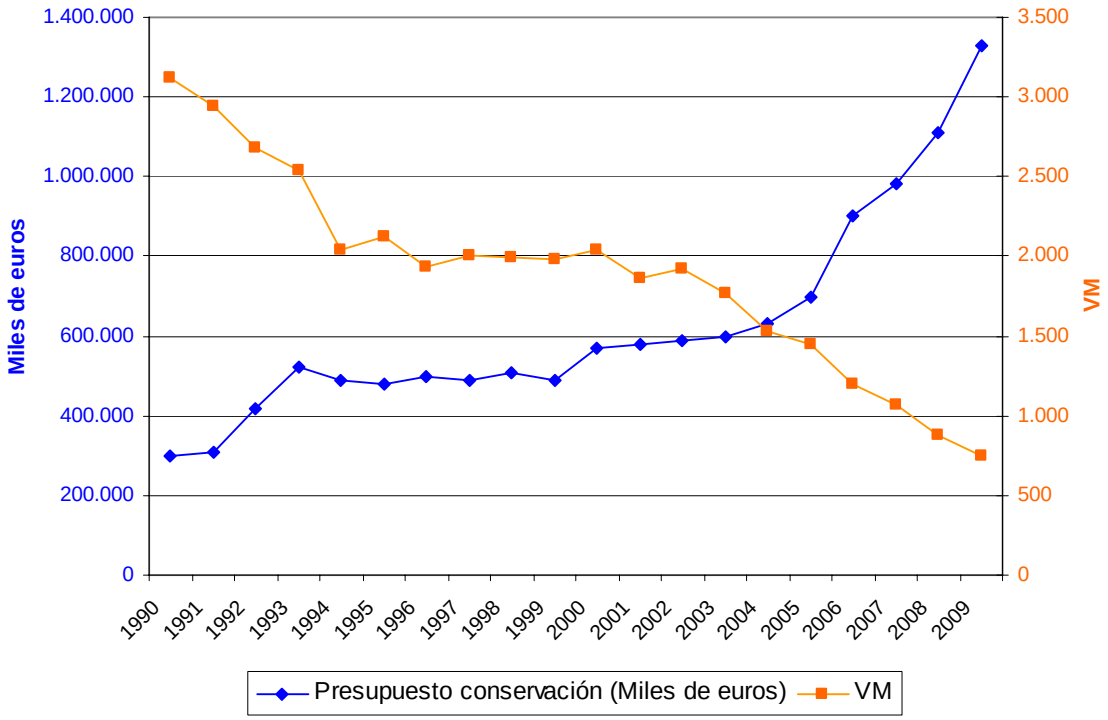

Figure 2 Correlation between proposed resources for network maintenance and road mortality

Therefore, in order to achieve the objective of reducing the number of accidents, a series of procedures are being adopted which are aimed at taking road safety into account from the very construction of the road, and throughout its years in service, covering all the stages of the planning, project, construction, putting it into service and its maintenance.

In the planning phase, a specific procedure is being developed for the evaluation of the impact on road safety in the new infrastructures and on the conditioning of the existing ones. This will allow the reduction of the accident rate of different proposed alternatives to be assessed so that this can be taken into account as one of the deciding factors when planning the alternative.

In the project and construction phases a road safety auditing system is being established that includes a different part of the process from that of the design phase. In this system, an independent team of experts in road engineering and road safety revise the configuration of the physical elements of a road and its correlations. The aim is to detect potential safety risks for users and to offer recommendations to the planning and project team on appropriate measures to be taken in order to avoid these risks, before the construction phase is reached.

Lastly, in the existing roads there are already procedures in place for identifying and treating those sections of roads with high accident concentration sections and carrying out periodic inspections and classification of network security levels. The aim is to detect faults or potentially dangerous elements for road safety and to correct these as well as to establish action priorities in those sections with a high potential for improvement.

2. CLASSIFICATION OF NETWORK SECURITY LEVELS AND DETECTION OF SECTIONS WITH A HIGH POTENTIAL FOR IMPROVEMENT

In Spain, annual road safety improvement programmes have been carried out since 1986. These programmes include actions aimed at resolving problems with high accident concentration sections and improving preventative road safety conditions, overcoming any faults detected in order to reduce the potential risk of accidents in the Network as a whole. The treatment of the high accident concentration sections considers a set of highly efficient actions which affects approximately 5% of the network, in which 20% of the accidents with victims and 15% of fatal accidents are produced. Every year, the Ministry of Public Works identifies these high accident concentration sections, taking into account not only the accidents registered in a 5 year period, but also other variables such as the Annual Average Daily Traffic (AADT), the type of road and the environment (urban, interurban or periurban). Once these sections have been identified, a study is undertaken by engineers who specialize in road safety studies, who inspect each one of them, undertaking an analysis and security diagnosis from which the actions to be taken for its treatment and improvement are derived. However, it should be taken into account that, despite the efficiency of the action on the high accident concentration sections, the other 80% of accidents and 85% of fatal accidents occur in the rest of the network. It is in these sections where preventative measures are developed, aimed at eliminating potentially dangerous elements of the infrastructure, and standardizing the characteristics of the network by improving it before accidents take place.

The General Management of Roads of the Ministry of Public Works has developed a classification procedure of the levels of road safety of the sections of the Network. This constitutes the first step of a comprehensive safety analysis of the network in service. The results of this analysis allow measures of improvement of the infrastructure to be proposed,

costs to be estimated and the potential reduction of accidents to be established, so that the necessary information is available for establishing priorities for carrying out safety improvement measures in accordance with the benefit-cost ratio. The overall procedure is therefore aimed at maximizing the social profit of the resources dedicated to the improvement of road safety on the roads in service. The components of this procedure are the following:

a) Classification of the network in categories of comparable sections.

b) Sectioning of the network into standardized sections in accordance with safety related factors, such as type of road, traffic volume and type of traffic.

c) Estimate of the potential reduction of costs of accidents attainable in each section of the network by means of improvements in the infrastructure. The potential for security is calculated as the difference between the cost of the accidents per km of the section during the revision period and the expected costs for roads of the same type with better safety conditions.

d) Selection of the sections in which the potential reduction of costs of accidents is higher in order to carry out more detailed studies.

e) The expected name for these sections is “sections with a high potential for improvement in road safety”.

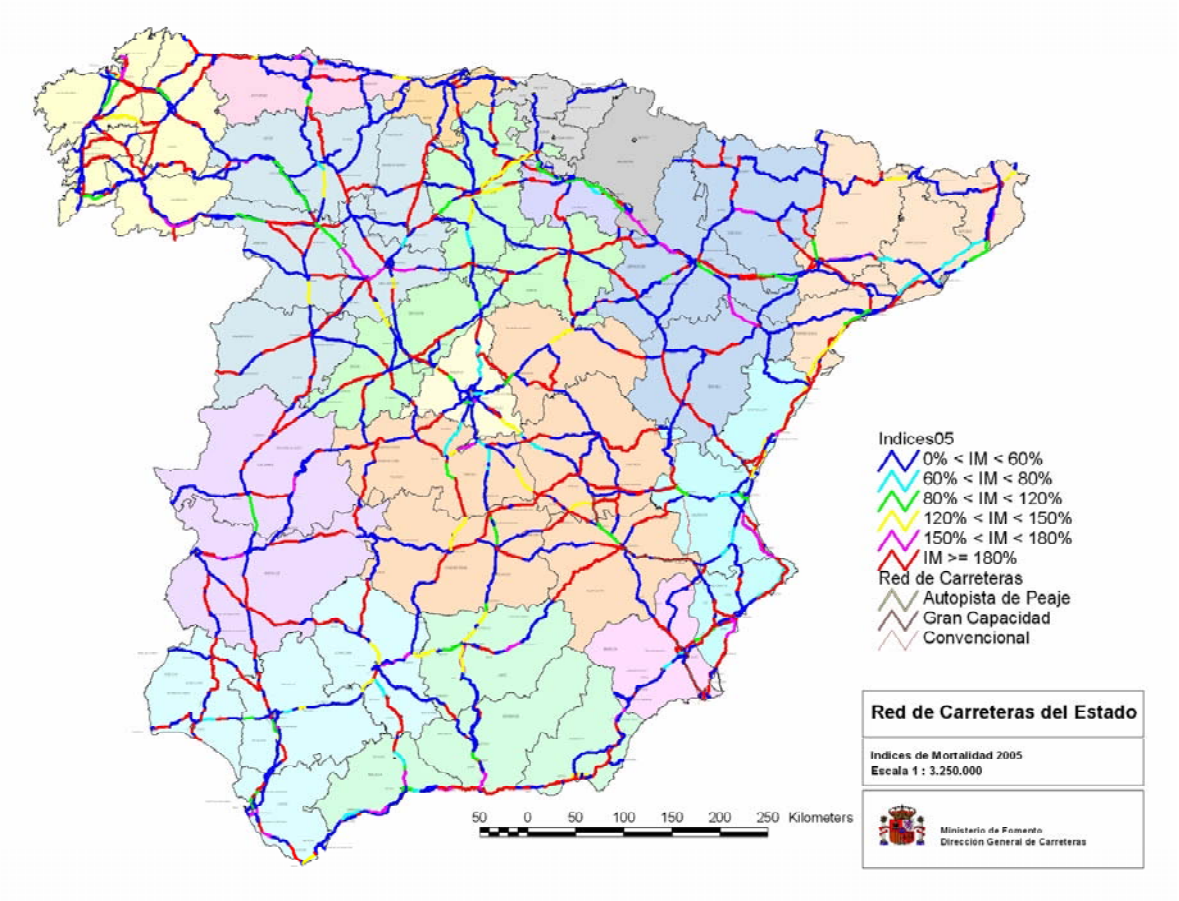

Figure 3 Classification of priority sections of the network for preventative measures of road safety

3. GEOGRAPHIC INFORMATION SUPPORT SYSTEM FOR NETWORK ROAD SAFETY INSPECTIONS

The road safety inspections carried out in Spain consist of a process in which a team of road safety experts systematically revise the physical elements of the road infrastructure (its physical characteristics as well as geometric characteristics and equipment) and its correlations for detecting potential risks for road safety. The main results of the data taken on site during the inspection and subsequently dealt with in the office are the following:

- General road inventories: sections, intersections, links, crossings, etc.
- Inventories of security elements: restraining devices, existing speed limits; overtaking prohibitions; beaconing on bends; danger warning signs, etc.
- Database of elements to be improved.

Due to its flexibility, a Geographic Information System (GIS) has been used in order to manage all the information generated during this complex road safety process.

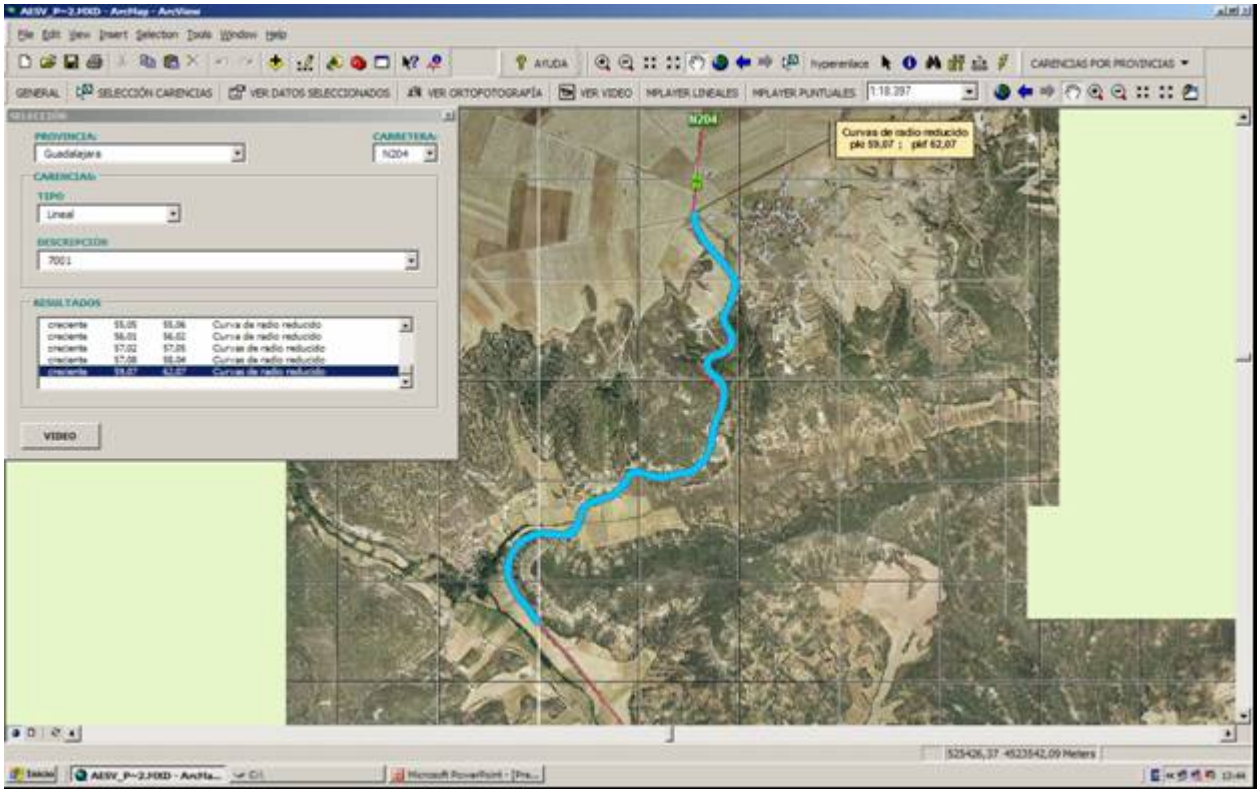

Figure 4 Consultation of the GIS which supports the road safety inspections

The system makes undertaking inspections easier as there are three automatic functions to be gained from its use:

1. Storing of information: the system allows the information which is stored during the inspection phase to be stored in a database organized in the necessary tables

(thematic tables of improvable elements, geometric characteristics, speeds, traffic, accidents, etc) and referenced to the coordinates taken with the GPS on the road.

2. Work tool: the development of small applications allows information to be directly obtained in relation to the route, the visibility distances, etc., identifying improvable elements, as well as directly assigning kilometre points to elements identified in the video.

3. Results generator: the possibility of editing reports filtered through the different fields of each table allows an adequate management of the analysis results, being able to edit the information by zones, sections, element, etc.

In addition, it is also possible to automatically incorporate other external databases that although not necessary for carrying out the road safety analysis, could be useful for the final processing of the information.

4. AUTOMATED PROCEDURE FOR THE DESIGN OF PREVENTION MEASURES OF SUN GLARE IN CRITICAL SECTIONS

Sun glare in sections of the road which are critical for safety such as tunnel exits or entrances from minor roads onto major roads and junction turn offs pose a risk for road safety. In the Polytechnic University of Madrid a computer tool has been developed which identifies and assesses sun glare problems. This then facilitates the measures design to be undertaken in order to avoid road safety problems in these situations. The programme is based on a methodology previously developed at the University with financing from the Ministry of Public Works which calculates the days or hourly intervals of the year when the sun may affect drivers´ vision on certain sections of a determined stretch of road, depending on the geographic location, its geometric design and the physical characteristics of the area. In order to obtain the values of the variables of the problem that depend on the configuration of the land and on the geometry of the road, an independent module has been developed which is part of a geometric roads design computer programme.

The analysis of sun glare is carried out by the variables involved in the problem being represented in cylinder charts. In addition to the solar paths throughout the year, other variables of the problem are the direction of the driver’s line of vision, the glare cones and the visual obstructions. A glare cone is a cone whose axis corresponds to the driver´s line of vision, and whose angle represents the limit at which a driver stops seeing objects in their field of vision when the sun is in it. The value of this angle depends on the driver´s characteristics, mainly their age.

In Figure 5, we can see the representation of the variables on a cylinder chart in which the variables are shown in a cylinder which surrounds the driver adopting a uniform scale for the axis of ordinates.

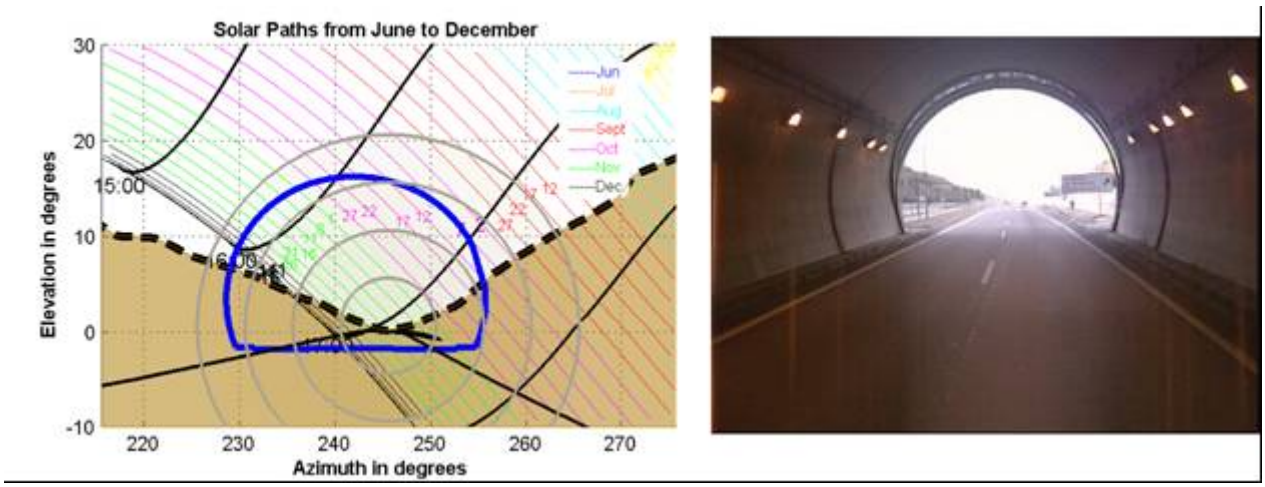

Figure 5 Representation of determining variables of sun glare problems in a cylinder chart

The position of the sun at a particular moment is represented by a point with its azimuth in the axis of abscissas (x axis) and its elevation in the axis of ordinates (y axis). The solar paths have been represented in the cylinder chart for different days of the year. When the driver is in a certain position, there may be elements which protect him from the rays, such as aspects of the land or a tunnel duct or plantation and artificial elements which offer protection. Each one of these elements is represented in the cylinder chart by means of a line which separates the areas in which the driver is protected from the sun by the aforementioned elements from the areas in which the driver is not protected. The direction of the line of vision remains represented by a point and the glare cone by means of circles with the centre being the driver´s bearings.

The methodology allows the problems present at the tunnel exits to be dealt with, and a procedure to be provided in order to study the measures design to deal with sun glare and to evaluate its efficiency. This methodology was applied in the analysis of the problems of sun glare in the Miravete Tunnels, in the A-5 motorway, and in the consistent measures design in plantations on the roadsides and on the roads (Figure 6).

The methodology that was initially developed did not allow the prolonged exposure to sun glare whilst travelling along a section of road to be taken into account, that is, when the sun is in the driver´s field of vision during a long, uninterrupted period of time. A new procedure was developed for this in order to analyze these situations, which can be applied to already existing roads as well as to newly designed roads. In the design phase, the procedure allows the project team to analyze the impact of prolonged exposure to sun glare in drivers, allowing this factor to be considered when it comes to comparing different route alternatives. In addition, the efficiency reached with the introduction of measures for dealing with sun glare can be quantitatively evaluated, generally consisting of plantations at the sides of the roads. The computer tool developed has been applied in Spain in various specific studies of singular locations in which sun glare generated risk, such as tunnel exits, motorway slip roads and on the approach to intersections. It was also used in the analysis of the impact of sun glare and the measures design in the A-58 motorway between Trujillo and Cáceres.

Figure 6 Plantations in the Miravete tunnel (A-5 motorway)

5. AUTOMATED EVALUATION PROCEDURE OF THE CONSISTENCY OF THE ROAD

The results of a series of investigations carried out in different countries coincide in highlighting the importance of respecting the driver´s expectations. The consistency of the road may be defined as the level of agreement between the geometric characteristics of a road and the characteristics the driver of a vehicle driving on that road would expect to find.

Whilst driving, drivers adapt their driving to the conditions they come across during their journey. When the route corresponds to one the driver expects to find, the road is consistent, reducing the possibility of errors and unsafe manoeuvres being committed. If the road does not respond to the driver´s expectations, the probability of risky manoeuvres such as hard breaking or sudden changes of route being produced will increase.

The specific decrease of speed of a given part of the road with respect to adjoining sections is one of the characteristic variables of the road which presents a higher correlation coefficient with the dangerousness index. In accordance with a study carried out by the Polytechnic University of Madrid and the General Management of Roads of the Ministry of Public Works, the regression curve between the two variables on the roads of a carriageway of the State Network increases uniformly with the specific reduction of speed with respect to the adjoining sections. With anything above a 30km/h reduction in speed, the regression curve increases noticeably. The reduction of the characteristics of the section causing this limit to be exceeded should therefore be avoided. The transition should be as gradual as possible.

At the Polytechnic University of Madrid with financing from the Ministry of Public Works and the Asociación de empresas de conservación (ACEX) (*Association of maintenance companies*), a programme for the detection and automatic analysis of road related safety problems has been developed which is made up of the following components:

- Detection algorithm of elements in which the reduction of driving speeds with respect to adjoining elements exceeds the recommended safety limits. The tool allows for the identification of high risk sections of the road due to inconsistencies on the road, which may oblige drivers to suddenly and significantly reduce their driving speed.

- Detection algorithm of sections with ramps in which the difference in speed between heavy and light vehicles exceeds the recommended safety limits in accordance with the conditions of the section (length, visibility, etc.).

Finally, the programme obtains various graphic outcomes with the speed profiles corresponding to different percentiles of the speed distributions. The programme uses the regression models weighed up with the data from the capacities plan for the speed curves, combined with the acceleration and deceleration of the vehicles. In Figure 7 an example of the outcome of results is shown.

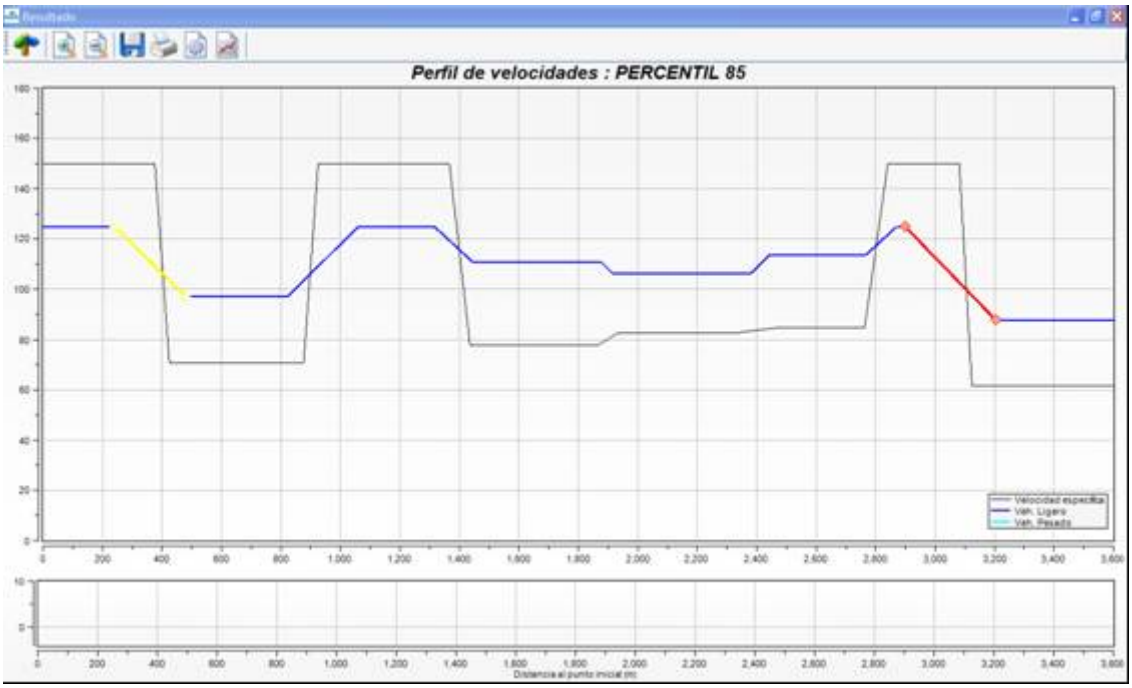

Figure 7 Graph of results of the analysis programme of the consistency of the road

In the profile a red, yellow and green line is shown when the changes of speed exceed the limits, that is, the vehicles have to decelerate too much. For example, when changes of speed of more than 30km/h are shown, this deceleration will be marked with a red line; in yellow if the change is between 20 and 30 km/h, and in green when it is between 10 and 20 km/h.

In addition, a profile is also shown with the specific speeds for the road. These speeds are calculated according to the regulations criteria, but taking into account the real banked curve of the road and the maximum values of the mobilized cross friction specified in the regulations. These allow the values to be compared (to see that they are appropriate values for comfortable driving) with the real driving speeds.

6. SYSTEM OF SPEED CONTROL BY RADAR STATIONS AND AUTOMATED SPEEDING OFFENCES MANAGEMENT SYSTEM

In 2005, the Spanish Traffic Management Centre established a set of measures aimed at reducing the high accident rate on the roads. Amongst these measures, the triennial Plan 2005-2007 for the installation of speed control points stands out, which generated 518 Speed Control Cabins equipped with 280 cinemometers.

The main objectives of the Plan were the following:

- To reduce the maximum driving speeds and to eradicate the particularly high ones.
- To reduce the average speeds on the roads.
- Reduction of speed gradients.
- The reduction of the number of surveillance officers specifically engaged in speed control, making a larger presence possible on the road for other services.

The “Estrada” centre is a Data Processing Centre which has been in operation in Leon since March 2008 for the treatment of photographs of speeding offences and the processing of the corresponding fines.

The photographs captured and the registers of traffic data are sent by each cinemometer to the corresponding Traffic Control Centre. This facilitates the maintenance of the equipment which is carried out in each management centre. Surveillance is also carried out using video surveillance cameras which the equipment is fitted with as a deterrent to acts of vandalism. In each traffic control centre the information is stored and transmitted to the Estrada centre by means of a 2mn/s link.

The files are managed in the Estrada centre, which returns to the radar coordinating centre, situated in the traffic control centre in Madrid, information about the files processed daily during different periods of the day: daytime photos, night time photos, at different times of the year etc. At the traffic control centre in Madrid, the ratio of effectiveness of each cinemometer in each of the three aforementioned periods is compared with this information, which facilitates the maintenance of the equipment and possible adjustments of the characteristics of the camera and strength of the flash. The correct state of the flash is also tested three times a day by means of direct access from the traffic control centre to the cinemometer.

Each piece of equipment is fitted with an anti-vandalism system with different sensors. Any strike to the cabin generates an alarm from the vibrations of the equipment which is immediately sent to the traffic control centre. The equipment also has cameras which permanently record and in the case of any alarm, sends the corresponding recording of the minute preceding the setting off of the alarm to the traffic control centre.

An analysis of the results obtained allows us to reach the following conclusions:

- The maximum speeds captured in our network are clearly lower than those registered at the beginning of the Plan.
- The average speeds have been reduced significantly, not only at the speeds control points, but in the network as a whole.
- The number of victims of fatal accidents on the road has decreased noticeably.

In Figure 8 the evolution of the average speeds from the establishment of the system can be observed. We can see an important, significant decrease from the data in the maximum speeds as well as the average driving speed. This decrease in the speed gradients has created a very positive change in the behaviour of the drivers as can be seen on our roads.

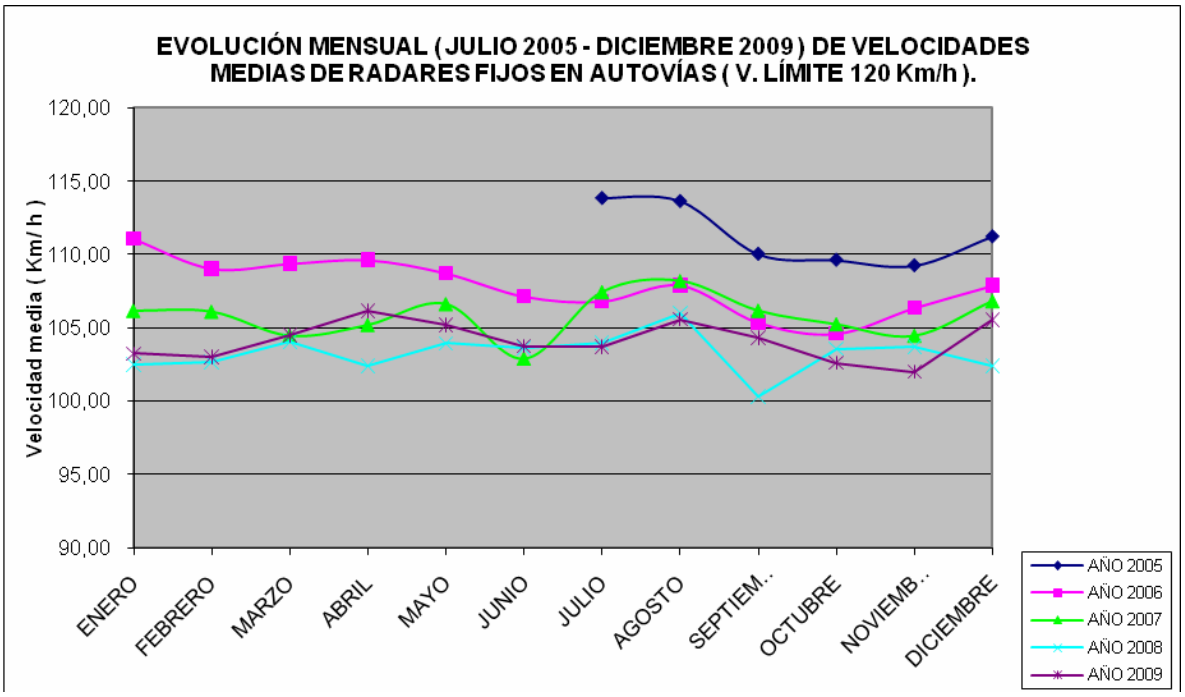

Figure 8 Evolution of the average driving speeds from the establishment of the speed control system at different radar stations

7. RESULTS OBTAINED IN ROAD SAFETY IN SPAIN

The overall application of the measures which were set out in the framework of the Strategic Plans of Road Safety and of Infrastructures and Transport have resulted in an important improvement of road safety in Spain in recent years. Figure 9 shows the evolution of the figures of fatal accident victims registered in the whole Spanish road network from 2000 to 2009. From this the important decline registered from 2003 can be appreciated, which has led to more than a 50% reduction of fatal accident victims in 2009 – 52.4% - a year ahead of the objective set by the European Union.

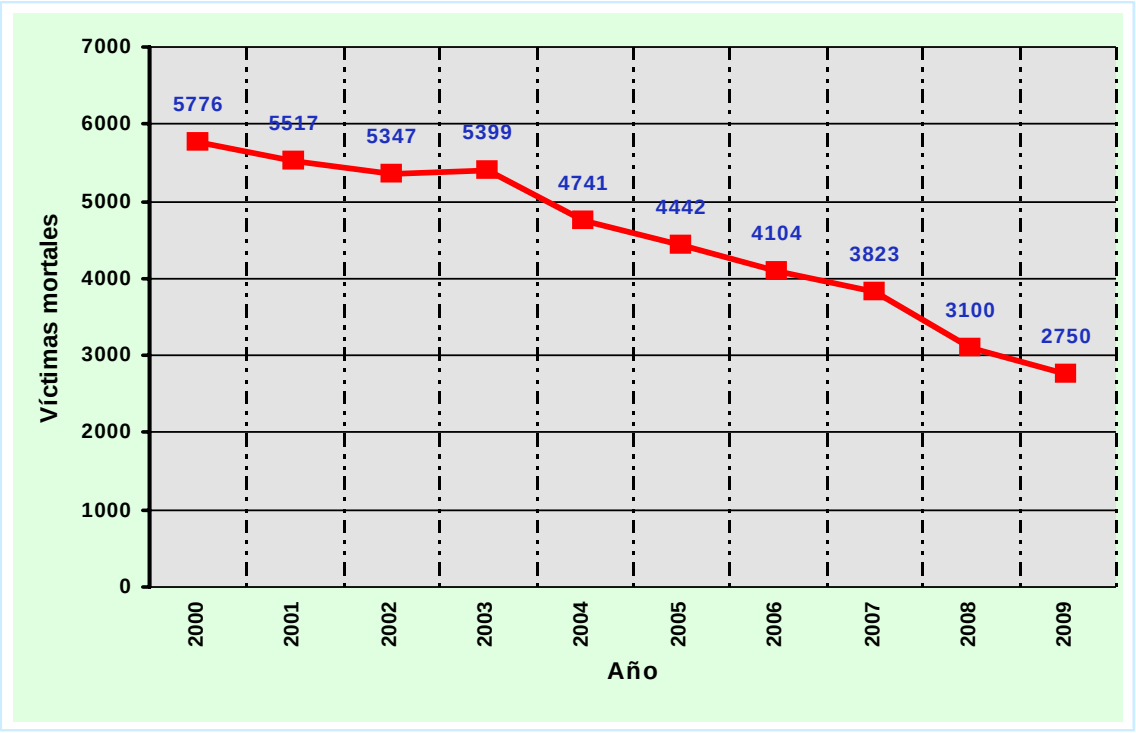

Figure 9 Evolution of fatal road accident victims in Spain in the period 2000-2009

Equally, the evolution of the rate of accidents has been very positive in the national road network (State Road Network). In the period 1991-2009, the dangerousness index (number of accidents with victims per hundred kilometres travelled) in 2009 was three times less than in 1991 and the mortality rate (number of deaths in accidents per hundred kilometres travelled) was 9 times less. The aforementioned indexes went from 31.5 to 4.3 and from 9.3 to 0.5 respectively. In Figure 10 the annual evolution of the dangerousness indexes and mortality in the period 1991-2009 is reflected.

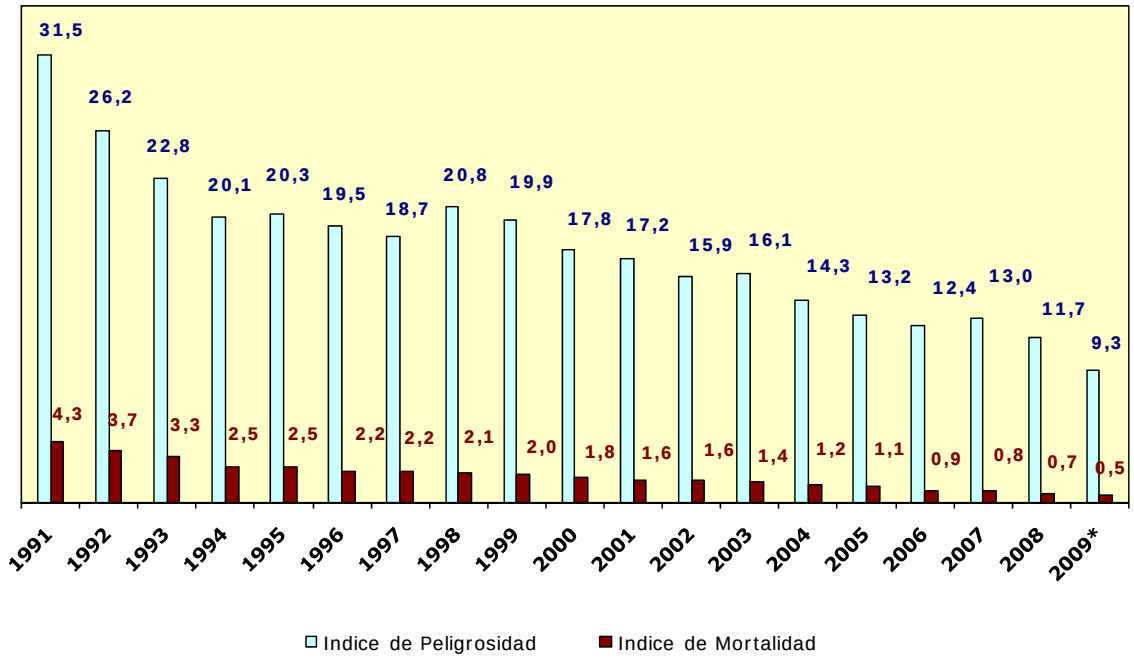

Figure 10 Evolution of the dangerousness indexes (accidents with victims) and of mortality rates (fatal accident victims/ 10^8 veh-km) in the National Road Network in the period 91-09

In conclusion, it can be affirmed that the improvement strategy of road safety carried out in Spain in recent years has reached its planned objectives, including ahead of the planned dates, highlighting the importance of acting together and coordinating on all aspects of road safety. An important contribution to this improvement in road safety in Spain has been the investment effort made in improving and modernizing the road infrastructure, by means of the construction of new infrastructures, population variants, the increase of investment dedicated to maintenance – reaching 2% of the asset value of the network – and to specific actions of security improvement derived from inspections and detailed analysis of the accident rate by a team of experts (elimination of sections of high accident concentration sections, preventative measures,....)

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