D2.3 Report for Spain on tailoring the methodology to national and regional needs and how to improve and develop the methodology
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Abbreviations and Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Abreviation</th>
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<tbody>
<tr>
<td>DGT</td>
<td>DIRECCION GENERAL DE TRÁFICO</td>
</tr>
<tr>
<td>RACC</td>
<td>REIAL AUTOMÒBIL CLUB DE CATALUNYA</td>
</tr>
<tr>
<td>SLAIN</td>
<td>SAVING LIVES ASSESSING AND IMPROVING NETWORK SAFETY</td>
</tr>
<tr>
<td>TES</td>
<td>TERRITORI I SOSTENIBILITAT DEPARTMENT</td>
</tr>
<tr>
<td>GENCAT</td>
<td>GENERALITAT DE CATALUNYA</td>
</tr>
<tr>
<td>TEN-T</td>
<td>TRANS-EUROPEAN TRANSPORT NETWORK</td>
</tr>
<tr>
<td>SRIP</td>
<td>SAFER ROADS INVESTMENT PLANS</td>
</tr>
<tr>
<td>RAP</td>
<td>ROAD ASSESSMENT PROGRAMME</td>
</tr>
<tr>
<td>KSI</td>
<td>KILLED AND SERIOUSLY INJURED</td>
</tr>
<tr>
<td>CGT</td>
<td>CENTRO GESTIÓN TRÁFICO-TRAFFIC MANAGEMENT CENTER</td>
</tr>
<tr>
<td>AADT</td>
<td>ANNUAL AVERAGE TRAFFIC FLOW</td>
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Executive Summary

Spain has wide experience in the application of EuroRAP methodology and the continuous development of new road audits allows the Spanish partners DGT, TES and RACC to take advantage of previous experience and go one step further, tailoring the methodology to national and regional needs and improving the methodology in different ways, to:

- develop country objectives and a strategy for the application of Star Ratings
- create a training course for the technical staff and subcontractors of public bodies and
- validate the methodology translating the results into political decisions.

The first part of this document is focused on the definition of the objectives of Star Ratings for Spain, analysing what the methodology can achieve in a road network and how the results of the assessment can be incorporated in road maintenance services in a doubly efficient way: to monitor the protocols and to optimise use of public funds for roads. To reach these objectives, the deployment of Star Ratings methodology can provide a consistent quality over wide-ranging safety criteria, together with standards applicable to all the road network.

From the perspective of the public authorities of Catalonia and Spain, the “3-star or better” Star Rating objective is not a key target in Spain. Rather, the objective is to seek a continuous improvement in the overall Star Rating of the roads studied. In addition, there is a role for the Safer Roads Investment Plans (SRIP), particularly in maintenance operations and assessing performance using cost benefit analyses. Within the SLAIN framework and not reported on in detail here, both public administrations will also offer suggestions for improving the Star Ratings methodology: DGT will be focused on supporting data (non-infrastructure attributes such as value of life, AADT or operating speed) and TES will develop an automated coding for the infrastructure data collection.

The second part of the document explains the contents of the training course for public bodies and subcontractors, prepared with the objective of promoting the EuroRAP methodology according to the country strategy described above. The training is at a technical level and it will be developed in Madrid in a two-day session during 2020, focusing on road survey and coding from one side and the development of SRIP using ViDA software from another side.

The third part of the report is a natural continuation: after setting the objectives and the country strategy and the development of training for the technical staff, the next part describes the process of analysis of the results from the engineering side to political decisions. This process is intended to steer the allocation of the road maintenance budget according to evidence-based results provided by the EuroRAP methodology. As part of this, an innovative methodology demonstrating the combination of historical crash data and Star Ratings resulting from existing data has been developed. Its application is intended to demonstrate the role of the Star Ratings as a useful tool in the process of assessment of road infrastructure improvements.
1. Define final objectives of Star Ratings for a public administration

The main goal of this chapter is to detect what the objectives of the application of Star Ratings methodology are for a public body, using the wide experience of TES on how it intends to integrate Star Ratings methodology into the existing protocols. First of all, the supervision and conservation of TES road network must first be put into context what the road network is and how it is managed.

The TES road network is just over 6,000km long and supports an average traffic intensity of 7,400 vehicles / day. This means that more than 540 million trips are made each year, and almost 50 million tonnes of goods are transported there. In terms of the functional aspect, it consists of 740km of divided carriageway roads and 5,270km of single carriageway roads.

The network is divided into several areas in order to properly manage this network and to be able to do the maintenance operations with a good quality standard. Specifically, TES has it divided into 5 territorial units that group 17 areas of road conservation.

In these areas of conservation work 195 field workers, who are part of the staff of the Generalitat and 260 external workers, linked to all external contracts for support of their own staff. These external contracts are:

- 17 contracts for civil works (1 per area)
- 5 contracts for lighting maintenance (1 per territorial unit)
- 5 contracts for road marks maintenance (1 per territorial unit)
- 10 contracts for pavement maintenance
- 6 contracts for geotechnical assets maintenance
- 6 contracts for structural assets maintenance
- 3 specific contracts for motorways and tunnels

To properly manage this complicated mix of our own staff with so many external contracts (52 in total) there is a Road Control Centre in Vic, a municipality in the province of Barcelona, located approximately in the geographical centre of Catalonia, from which TES centralize all the information regarding incidents that occur on the network and that enable the appropriate teams to respond to such incidents.

The TES protocols allow both our own staff (and linked to external contracts) and staff of the emergency services (firefighters, police and other bodies) to notify the Control Centre of any incident that occur on the network. The Control Centre confirms that the road where the incident took place belongs to the TES and communicates it to the person in charge of the
appropriate maintenance team in the field.

![Figure 2 Road Control Centre sited in Vic](image)

In a standard year, 7,000 to 8,000 incidents occur on the TES road network. As a support tool for correct maintenance management, the TES has various asset management systems that allow us to have the inventory information and status of each of the functional assets of the road. Hence TES has, among other things:

- Structure management system, with more than 3,500 inventoried and inspected structures.
- Pavement management system, with auscultation data every 10m of the entire road network with updated data every two years. The system allows to predict the evolution of the state of the firm for up to 5 years as seen in the non-performance hypothesis
- Management system for civil works conservation operations
- Road safety management system, with historical crash data
- Geotechnical asset management system (incidents due to landslides or rockfalls, and an analysis can be performed that determines the risk of new incidents)
- Gauging management system, with historical data of traffic intensities, velocities, etc.

![Figure 3 Images of the Structural Assets Management System of TES](image)
Figure 4 Graphics from Pavement Management System

Although this management system has given us very good results, it has some important difficulties that we need to solve:

- TES has more than 30 people with responsibilities when it comes to conservation. Each has different knowledge and training, different responsibilities, and most importantly, different sensitivities to what needs to be done. This situation leads to difficulties in establishing homogeneous criteria regarding the quality standard of the network that must be achieved. In fact, the criterion is currently heterogeneous in the territory, which from the point of view of the road user cannot be admissible.

- TES has too many different management systems, in which each of them incorporates their individual risk analysis on their work assets, but they are specific analyses without direct relation to the other assets, and all the functional elements of the road are linked and interrelated with each other, so we need a tool that allows us to analyse all assets together, without losing the specific analysis capacity that these management systems currently have.

- We do not have enough budget to transform and improve the quality standard of the road network through the bidding and execution of projects and works as has been done traditionally. Hence, a major way to improve road safety is through maintenance work.
- Managing nearly 200 staff members and 52 external support contracts further impedes the establishment of homogeneous quality and safety criteria and standards applicable to the entire road network.

Given these difficulties and having analysed the virtues of the Star Rating methodology, it is clear that the implementation of the system within the TES road network conservation protocols should allow us to:

- Combine all the data that we have in the different management systems and draw more accurate conclusions about what is happening in the network and therefore make better decisions when investing the conservation budget.

- Perform the cost-benefit analysis of conservation operations, in terms of road safety and not only within the scope of each management system associated with specific risks. Then the planning of the conservation work will be more efficiently and obtain the best combination of personal work and external contracts.

2. Spain: Country strategy for the implementation of Star Ratings

At this time, the “Spanish Road Safety Strategy 2011-2020” is the document followed by the Spanish administrations. This document collects and integrates all the measures developed by the state general administration in order to improve road safety. This strategy promotes and boosts the initiatives of the rest of the public administrations with competence in this matter.

The aim of this strategy is to reduce the socio-economic impact of road traffic crashes, focusing on the following fields of activity:

1. Protect the most vulnerable users.
2. Promote safe mobility in urban areas.
3. Improve the safety of motorcyclists.
4. Improve safety on single carriageway.
5. Improve safety on work-related trips.
6. Improve conduct related to alcohol and driving speed.

The Spanish Road Safety Strategy 2011-2020 follows the guidelines from:


- First Global Ministerial Conference on Road Safety, known as “Moscow Declaration” by United Nations of 20 November 2009. Participants called for action to address the large and growing global impact of road traffic crashes, reviewed progress on implementation of the World report on road traffic injury prevention and shared information and good practices on road safety. The Moscow Declaration recognized that road safety is a “cross cutting” issue which could contribute significantly to the achievement of the old United Nations objectives (Millennium Development Goals).
Moreover, the Moscow Declaration invited the United Nations General Assembly to declare the decade 2011-2020 as the “Decade of Action for Road Safety” with the goal of stabilizing and then reducing the forecasted global road deaths by 2020.

The Spanish Road Safety Strategy includes 11 areas of action in order to reach the strategy objectives. Each one of the 11 areas of action is developed into areas of intervention and concrete actions. One of these areas of action is “Infrastructure and Intelligent Transport Systems (ITS)”, which contains 4 areas of intervention such as “Safe infrastructure design”. This area of intervention includes the following action:

- Incorporating the assessment of impact on road safety in the planning of infrastructure and road safety audit in the early stages of design and construction of new roads or substantially modifying existing ones, as advocated by the European Directive on Safety Management road infrastructure.

- Reviewing the criteria for the organization of roads and their determining factors.

In this context, the traffic management authority DGT (Dirección General de Tráfico) has applied the EuroRAP methodology which measures risk assessment for vehicle occupants, motorcyclists, pedestrians and bicyclists through infrastructure analysis. This measure was taken in 2017 by Spanish National Government as an urgent step to assess road safety by an infrastructure analysis and a Star Rating score.

A common political decision around EuroRAP methodology is to set annual goals for improving road safety through road safety work. A good goal could be to achieve a 3-star or better network as EuroRAP suggests, it has been adopted by several countries with a wide experience in road safety innovation and achievements such as the Netherlands. However, from the public authorities of Catalonia and Spain, the 3-star or better objective is not a key aspect, but a continuous improvement in the overall Star Rating is a key target.

Now, the Spanish Management Authority is in the process of drafting the new Spanish Road Safety Strategy 2021-2030. This strategy will follow the guidelines from Directive (EU) 2019/1936 of the European Parliament and of the Council of 23 October 2019 (amending Directive 2008/96/EC on road infrastructure safety management) and United Nations 2030 Agenda for Sustainable Development (in detail 3.6 and 11.2 Sustainable Development Goals). Concurring with this new strategy drafting, the United Nation “Decade of Action for Road Safety” (included in “Moscow Declaration”) will be finished this year. Therefore, the road safety measures should be studied to value the progress.

The main objective is to move close to zero fatalities by 2050 and halving the number of serious injuries by 2030 compared to 2020. The protection of the most vulnerable users is one of the priorities of the new Spanish Strategy, because 48% of traffic fatalities are vulnerable users (motorcyclist, bicyclist and pedestrians). Some measures could be taken in order to provide safe areas for pedestrian and bicycle mobility and also improve knowledge concerning the crash rate of pedestrians, bicycle and motorcyclist.

The Spanish government and the regional government of Catalonia showed different strategies to improve data collection for the Star Ratings: on the one side, DGT has developed specific methodologies for obtaining supporting data inputs required in an EuroRAP project: value of life, annual average daily traffic, countermeasure cost, type of crashes and operating speed. On the other side, TES from the Catalan government is working on making the coding process more efficient with the double objective to reduce working time and avoiding potential mistakes during the process. Hence, the country strategy of Spain is covering all the Star Ratings methodology: the collection of external data and coding of road attributes.
2.1 Spanish government strategy

The main goal of the DGT strategy is to improve the supporting data collection, i.e. all data that is key for the results of the Star Ratings but that are not road infrastructure attributes. The following data are required in an iRAP project: value of life, annual average daily traffic (AADT), countermeasure costs, type of crashes and operating speed.

Value of life

Crash cost calculations are often based on a state of research, such as a specific choice of components or a method in order to find the right monetary amount of damages, efforts and any other disadvantages related to a road crash. During the last decades, one of the most discussed aspects of monetizing the level of road safety was the development of a Value of Statistical Life (VoSL). In the road safety area generally, pain, grief and suffering and lost quality of life, because of road crashes, shall be summed up within this value after monetizing them.

Different methodologies of monetizing can be distinguished in two general approaches throughout Europe: The Human Capital (HC) approach and the Willingness-to-Pay (WTP) approach. These costs could be updated depending on the variation of the type of victims and other items like demographic and economic data. The WTP approach, which is used by Spain in calculation costs, is based on the personal preferences of people. People show their willingness either to pay a specific amount of money (or generally: wealth and other benefits) for the reduction of a crash risk or to accept money for accepting the risk. Depending on the specific WTP method applied, the value is either estimated by asking directly or by deducing from choice experiments.

In 2010, Universities of Murcia and Pablo Olavide of Seville carried out a report funded by DGT using the WTP methodology. This report presented the estimation of the Value of a Statistical Life (VoSL) in the context of road crashes in Spain. This VoSL amounted to 1.3 million euro. After adding net output losses as well as medical and ambulance costs, a Value of Preventing a Fatality (VPF) of 1.4 million euro is obtained.

The VPF should be used to compute the social costs of fatal road crashes in Spain. Likewise, it could be used to assess the benefits of road safety measures in terms of saved lives, making possible the economic evaluation of Spanish transport policies.

The VPF is annually updated on an annual basis in line with the nominal GDP per head growth, that is, a factor equal to the average year variation in GDP. VPF amounts to 1.580.318 in 2018. Also, the unit cost of a slight injured person would be in Spain 6.886 € and a serious one would be 247.207 € in 2018. The costs per casualty used in Spain measured in euros (€) are shown in the table below.

<table>
<thead>
<tr>
<th>Type of victim</th>
<th>Value of life (€)</th>
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<tbody>
<tr>
<td>Fatality</td>
<td>1,580,318</td>
</tr>
<tr>
<td>Serious injury</td>
<td>247,207</td>
</tr>
<tr>
<td>Slight injury</td>
<td>6,886</td>
</tr>
</tbody>
</table>

Source: Main Figures on Road Safety Data. Spain 2018.
Where the ratios between slight injury and, serious injury and fatality are: 1/36 and 1/230 respectively. These are costs that any society cannot afford and that highlight the need to increase their prevention to reduce and avoid them in the short future.

**AADT: Annual average daily traffic**

The AADT data of: cars, good vehicles and motorcycles, are obtained by data collection electromagnetic loops stations of traffic management authorities and national, regional or provinces authorities. After that, this information is collected in a Database to be used later.

These attributes are collected for:
- Criteria to select the road network and sections for develop iRAP Project (AADT averaged per length > 2,000 vehicles/day) using the following formula.

\[
AADT = \frac{\text{Length}_i \times \text{AADT}_i}{\text{Total Length}}
\]

*Figure 5 Formula AADT averaged per length*

- Supporting database in a .xlsx file -> AADT Each 100 m of length

**Countermeasure cost**

DGT has defined more than 90 countermeasures to be used as a basis for Spanish Safer Roads Investment Plans (SRIP). These countermeasures that can be included in iRAP project to improve the road safety of one or more users (vehicle occupant, motorcyclist, bicyclist and pedestrian). Based on the analysis of the unit prices developing a Spanish national database, each countermeasure is broken down into budget per activity.

These countermeasures are structured in the five sections: Scope of treatment, cost of the measure, aspects of implementation, benefits and example images of the countermeasure.

The information included in each countermeasure is:
- Identifier number and countermeasure name.
- Service life (years duration treatment): estimated between 1 to 20 years.
- Unit cost:
  - Per km: measure per km, e.g.: rumble strip, central hatching, bicycle lane.
  - Per linear km: measure just one side of the carriageway (driver or passenger), e.g.: roadside barriers - driver side, roadside barriers - passenger side.
  - Lane km: measure per one lane, e.g.: improve delineation, pave road surface. After will be multiply depends on the name of lanes.
  - Intersection: per intersection, e.g.: roundabout, grade separation.
  - Unit: per element, e.g.: signalized crossing, refuge island.
  - Area type: Rural or Urban.
- Upgrade cost: records the influence that the surrounding land-use, environment and topography will have on the cost of major works.
  - High cost = Medium cost + 10% x Medium cost
  - Medium cost
  - Low cost = Medium cost – 10% x Medium cost

So that, allowing for different Upgrade costs and Area types, we then have 6 different prices for each countermeasure depending on the Urban/rural and the difficult to build at the
roadsides, for example, the available space may be high cost for bridges, rural roads close to rivers, tunnel or in a village close to the buildings. A way to calculate them is using prices of different road works developed in the country and obtained and average value. A brief review of the countermeasures is included in Section 5.4. of this document.

**Type of crashes**

Firstly, the traffic police must collect data crash on-site including many topics like: province, city, road name, start and end chainage, direction, latitude, longitude, year, month, date, hour, type of victim (fatal, severe injured or minor injured), type of crash (run-off driver-side, run-off passenger-side, head-on overtaking, etc) and type of user (vehicle occupant, motorcyclist, bicyclist or pedestrian). After that this data must be uploaded to a crash database, previously created, to be queried for the project.

**Operating speed**

The operating speed (km/h) must be collected also each 100 m of length. Two different speed data are required:
- Mean: average operation speed of the vehicles.
- 85th percentile (V85): speed at which 85 percent of the vehicles are travelling at or below in free-flow using floating car data in real-time data.

This information could be collected by floating car data, from the aggregation of real speeds obtained directly from vehicles fleets and individual vehicles. The data are obtained by GPS sensors present in the vehicles (smartphones, navigator…).

### 2.2 Catalan government strategy

The main goal for TES is to achieve a homogeneous Star Rating Score across the network and to establish an annual improvement rate for this Score. The scope of 3 stars or better for a high percentage of the road network is a great idea for a public administration, but for achieving this goal, it will probably be necessary to boost the execution of works of extraordinary improvement and maintenance. Apart from the expected benefits of implementing the Star Ratings in the framework of road maintenance, one of the objectives of the implementation process is to make the most of all the work done over many years, making the most of it, giving it additional added value to which it already has.

According to TES vision, road maintenance is a dynamic process that involves daily actions that, in most cases, improve the safety of a road. Actions such as improving the signalling and marking of a curve, the replacement of a containment barrier, or the repair of potholes on the pavement are factors that directly affect the star rating score, and therefore, if we want to implement the ‘Star Rating’ as a commonly used tool in the maintenance context, it is important to find a way to easily and conveniently update the information entered in the calculation model, avoiding as much as possible duplication of work.

The usual scheme of feeding input data files for SRS determination is through a video recording and an accredited operator, who oversees transcribing everything that he sees in the recording into the archive. It seems clear that this data entry system may not be the one adopted in the context of maintenance, given that road parameters will be updated daily through maintenance operations.

For this reason, the road parameters that are part of the SRS calculation have been analysed, and TES has concluded that most of them are well collected and of very good quality in the TES-GenCat management systems. Therefore, within the SLAIN project framework, TES considers if possible the generation of algorithms that allow the automatic transfer of the data.
from these management systems to the data entry files by the SRS calculation. Once these algorithms have been achieved, the goal is to be able to make monthly or quarterly updates (depending on the stretch of road) of the SRS data entry files in order to have a traffic safety evolution indicator based on the conservation operations that may have been performed in this period of time. The technical development of this strategy will be deployed in Activity 7.6 on the automatic coding of the network for network-wide road assessment.

3. Training on road survey and road coding for Star Ratings

A training for DGT and its subcontractors will be developed during 2020 by RACC-ACASA to DGT and its providers (subcontractors) in Madrid during 2020. The contents of the training course are being developed by RACC-ACASA and includes all the phases of the project:

3.1 Road survey

The first part of the methodology is the road survey with the main goal of gathering all required information from the road network selected using equipped vehicle (Movitest) with a data software. The training is focused on the field work which includes the tasks related to the collection of data and conducting the surveys on the road but also the calibration of the system, selection of the road segments that will be assessed and all the constraints (rain, fog or night). The technology is usually composed by a mobile equipped van as well as software tools:

- Digital acquisition cameras.
- GPS antenna
- Odometer (calibrated)
- On-board software
- Heart-bet unit and curve alignment
The Movitest vehicle can circulate at the same speed of traffic, thus allowing a quick acquisition of field data without disturbing the traffic conditions. An onboard computer allows monitoring all the control parameters in real time, and also allows changing different acquisition variables depending on meteorology, speed limit, etc.

3.2 Road coding

The following stage of the training course is the road coding, the most important part as it is the part that require more time and more accuracy. The images collected every 10m during the road safety inspections need to be processed in a back-office software module, separately from the road inspection itself. By means of dedicated software, all the road safety attributes (a total of 52) will be stored in a database and will produce an output file that will be used to calculate the road safety action plan of the inspected road network.
Figure 9 Screens for coding

Road coding provides the core information for the Star Ratings calculations and the new EuroRAP Manual will be followed during the training course in Madrid.

In addition, to improve the understanding of the coding process, RACC-ACASA will use the coding simulator available at EuroRAP website using real-world pictures from the vehicle camera in road segments of Spain.

Finally, it is necessary to know that to obtain all road attributes, it will not need only the coded data, but also supporting data provided by the public authority which includes:

- Traffic volumes (annual average traffic flow, AADT)
- Crash data (location, types, modes, fatal and serious victims, etc) on the road network under study
- Real speed (V85 percentile)
- Costs of countermeasures and crashes according to national income level.

For the training course, the following materials will be developed and used:

- IRAP Survey Manual
- IRAP Coding Manual
- Presentation developed by RACC-ACASA
- Demonstrator ViDA using real images from Spanish road survey

4. Training on ViDA software

That part of the working process is developed at back office and it is divided into two different parts: Star Ratings and the Safer roads investment plans (SRIP). Both can be used as part of a systematic, proactive approach to road infrastructure risk assessment and renewal based on research about where severe crashes are likely to occur and how they can be prevented.

4.1 Star Ratings

Star Ratings involve an inspection of road infrastructure elements that are known to have an impact on the likelihood of a crash and its severity. The Star Rating of roads provides a methodology to measure the safety performance of a road network. This is particularly valuable where crash data records are unavailable or low quality. Inspectors record 52 road attributes known to influence the likelihood and severity outcome of road crashes. The road attributes are scored and combined to reflect the overall safety of the road for car occupants, motorcyclists, bicyclists and pedestrians.

Such scores are then assigned from 1 to 5 stars, allowing a cartographic presentation (see example below from the Spanish road network).
For the training course, the following materials will be developed and used:

- IRAP Star Rating and Investment Plan Manual (Beta version)
- Presentation developed by RACC-ACASA

4.2 Safer Roads Investment Plans (SRIP)

Safer roads investment plans are calculated by estimating for each 100m of roads the number of killed and seriously injured crashes (KSI) avoided by each of the 94 countermeasures.
considered in the iRAP catalogue. Only countermeasures that have proved to be effective reducing casualty crashes are considered by iRAP. The benefits over a 20 years period in terms of KSI saved are considered versus the cost of construction and maintenance of those countermeasures. The relation between cost and benefit (BCR: cost-benefit ratio) must be over a minimum threshold defined by public administration. Typically, BCR from 3 to 8 are considered to obtain several SRIPs with different amounts of investment.

The training is focused on the development inside the algorithm and also the use of the information of the ViDA software, but also a key aspect developed specifically for this training is the definition of what is and what is not a SRIP:

A SRIP is a road safety product that differences IRAP from any other model that may exist in the planning of road safety by means of the key factor: allocation of deaths and seriously injured that allow for an efficient planning for the reduction of the crash rate. It is also a prioritized list of improvement measures that have a cost-effectiveness that increases the Star Rating and reduces the risk related to the infrastructure based on an economic analysis of a series of measures performed by means of the comparison of the cost of implementing the countermeasure with the reduction of the costs of crashes that will result from their implementation. The SRIP includes engineering information, such as recorded attributes, proposal of countermeasures, economic assessments for each 100m section of the analysed network.

The SRIP is not intended as an engineering plan (a “bill of works”) that includes all the measures for the improvement of road safety as it is only a tool to show the most efficient measures to local engineers who are responsible for performing the constructive project (described in the next chapter of this document). Furthermore, the implementation of all of the SRIP measures (regardless of the selected BCR) cannot remove the deaths and seriously injured in a short term, but it can help to reduce them efficiently.

The SRIP and Star Ratings are iRAP products that are not delivered once and considered as finished. Instead, they are “living” documents that must be updated.

5. Analysis assessment final results from Star Rating and Safer Roads Investment Plans (SRIP)

The subtask index, of Spanish EuroRAP, is made up of: criteria to select the road network (Spanish crash rate 2019 in rural area, AADT, road authorities and road traffic management centers network); which is the Spanish road TEN-T network; the relationships between road iRAP network and road TEN-T; which are the results of an iRAP Project; how to compare crash databases and the SRS results and how Star Ratings and risk mapping can be incorporated to the Spanish Strategy.

5.1 Criteria to select the road network

The Spanish EuroRAP criteria to select the road network has been analyzed the Spanish crash rate 2019 in rural area, the AADT, the road authorities and the road traffic management centers network.

Spanish crash rate 2019

SLAIN

20

Version 1.1
The Spanish crash rate 2019, in rural area, has been disaggregated by type of victim, type of users and carriageway label type.

- **Type of victim (fatality and serious injury. FSI)**

The table shows the Spanish crash rate 2019 disaggregated by FSI, in number and in percentage.

<table>
<thead>
<tr>
<th>KSI</th>
<th>Number</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatality</td>
<td>1,098</td>
<td>20</td>
</tr>
<tr>
<td>Serious injury</td>
<td>4,395</td>
<td>80</td>
</tr>
<tr>
<td>Total</td>
<td>5,493</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Crash rate report 2019. DGT

It shows that, disaggregating the 5,493 FSI, that 20% (1,098) were fatalities and that 80% (4,395) were serious injuries.

- **Type of user**

The table shows the Spanish 2019 fatalities disaggregated by type of user, in number and in percentage.

<table>
<thead>
<tr>
<th>Type of user</th>
<th>Number</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle occupant</td>
<td>660</td>
<td>60</td>
</tr>
<tr>
<td>Motorcyclist</td>
<td>283</td>
<td>40</td>
</tr>
<tr>
<td>Bicyclist</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Pedestrian</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,098</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Crash rate report 2019. DGT

The table shows that, disaggregating the 1,098 fatalities users, the 60% (660) were vehicle occupants, and 40% (438) were motorcyclist, bicyclist and pedestrian, 283, 40 and 115 respectively. So, that 40% of fatalities were vulnerable users.

- **Carriageway type**

The table shows the Spanish 2019 fatalities in rural area type disaggregated by carriageway label, in number and in percentage.

<table>
<thead>
<tr>
<th>Carriageway</th>
<th>Fatalities</th>
<th>Fatalities (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Divided</td>
<td>298</td>
<td>27</td>
</tr>
<tr>
<td>Undivided</td>
<td>800</td>
<td>73</td>
</tr>
<tr>
<td>Total</td>
<td>1,098</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Crash rate report 2019. DGT
It shows that, disaggregating the 1,098 fatalities in rural area type, the 27% (298) were in a divided carriageway and the 73% (800) were in undivided carriageway.

**Annual average daily Traffic (AADT)**

Other criteria for the road network have been to select road sections with an AADT > 2,000 vehicles/day.

**Road authorities**

Other selection criteria for the road network have been to select by road authority.

<table>
<thead>
<tr>
<th>Area type</th>
<th>Road authority</th>
<th>Carriageway</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural / open area</td>
<td>National government</td>
<td>Divided</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Undivided</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Regions</td>
<td>Divided</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Undivided</td>
<td></td>
</tr>
</tbody>
</table>

The table shows that, the 10% selected was divided carriageway and the 50% was undivided carriageway, both of the national government road network. And the rest of the road network, 40%, was regional (divided and undivided carriageway).

**5.2 Road network by traffic management centres CGT**

The table shows, by traffic management center, the percentage of the road network selected, disaggregated by road authority and type of carriageway.

<table>
<thead>
<tr>
<th>Area type</th>
<th>Road authority</th>
<th>Carriageway</th>
<th>Suroeste (%)</th>
<th>Levante (%)</th>
<th>Pirineos (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural / open area</td>
<td>National government</td>
<td>Divided</td>
<td>14</td>
<td>28</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Undivided</td>
<td>33</td>
<td>32</td>
<td>43</td>
</tr>
<tr>
<td>Regions</td>
<td>Divided</td>
<td>19</td>
<td>18</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Undivided</td>
<td>34</td>
<td>21</td>
<td>36</td>
<td></td>
</tr>
</tbody>
</table>

It shows that the percentage of undivided rural area road network per traffic management center has been 67% (Suroeste), 53% (Levante) and 79% (Pirineos).
5.3 Road Spanish network: TEN-T (Comprehensive and Core)

The comprehensive network constitutes the basic layer of the TEN-T. It consists of all existing and planned infrastructure meeting the requirements of the Guidelines. The comprehensive network is due to be in place by 31 December 2050 at the latest.

The core network overlays the comprehensive network and consists of its strategically most important parts. It constitutes the backbone of the multi-modal mobility network. It concentrates on those components of TEN-T with the highest European added value: cross border missing links, key bottlenecks and multi-modal nodes. The core network is to be in place by 31 December 2030 at the latest.

Figure 12 Road Spanish TEN-T network
Source: www.fomento.gob.es

5.4 Road Spanish network: Relationship between road IRAP network and road TEN-T (Comprehensive + Core) IRAP network

Once the road network is selected, the influence of Trans-European Transport Network (TEN-T) in the iRap project has been measured.

Table 7 Comprehensive + Core network. Spanish iRAP Projects 2019-2020

<table>
<thead>
<tr>
<th>Traffic Management Center</th>
<th>Road IRAP network (km)</th>
<th>Road TEN-T (Comprehensive + Core) IRAP network (km)</th>
<th>Comprehensive + Core / IRAP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suroeste</td>
<td>3,266</td>
<td>930</td>
<td>28</td>
</tr>
<tr>
<td>Levante</td>
<td>3,088</td>
<td>917</td>
<td>30</td>
</tr>
<tr>
<td>Pirineos - Valle del Ebro</td>
<td>2,675</td>
<td>888</td>
<td>33</td>
</tr>
<tr>
<td>Catalonia</td>
<td>4,906</td>
<td>2,436</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>13,935</td>
<td>5,171</td>
<td>37</td>
</tr>
</tbody>
</table>

Source: DGT and SCT
The TEN-T road network that is analysed for each traffic management centre is defined in the table.

<table>
<thead>
<tr>
<th>Traffic Management Center</th>
<th>Road IRAP network (km)</th>
<th>Road TEN-T (Core) IRAP network (km)</th>
<th>Core / IRAP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suroeste</td>
<td>3,266</td>
<td>795</td>
<td>24</td>
</tr>
<tr>
<td>Levante</td>
<td>3,088</td>
<td>598</td>
<td>19</td>
</tr>
<tr>
<td>Pirineos - Valle del Ebro</td>
<td>2,675</td>
<td>576</td>
<td>22</td>
</tr>
<tr>
<td>Catalonia</td>
<td>4,906</td>
<td>1,133</td>
<td>23</td>
</tr>
<tr>
<td>Total</td>
<td>13,935</td>
<td>3,102</td>
<td>22</td>
</tr>
</tbody>
</table>

Source: DGT and SCT

As it can now be seen, 37% of the total road audited network in the iRap project is part of the Comprehensive and Core network. And, 22% of the analysed network is Core Network.

The last iRAP phase consists on analysing the results: Star Rating Score, the fatality and serious injured (FSI) estimation, predicted casualty reduction map and safer roads investment plan.

**Star Rating Score**

The SRS is calculated for each 100m segment of road for vehicles occupants, motorcyclists, pedestrians and bicyclists.

Star Ratings are calculated using the road attributes and corresponds to the relative risk of death and serious injury for an individual road user.

![Figure 13 Star rating score for each user](https://vida.irap.org)

Source: https://vida.irap.org and DGT

**Vehicle occupant Star Rating smoothed star**

The results include the SRS before and after of countermeasure implementation.
Before countermeasure implementation:

The next figure shows the vehicle occupant Star Rating smoothed star (to clarify the view), before implementation of the countermeasures, of the road section A-431 (Córdoba province) in CGT Suroeste.

![Figure 14 Vehicle occupant Star Rating smoothed star. Before](https://vida.irap.org)

Source: https://vida.irap.org and DGT

After countermeasure implementation:

The next figure shows the vehicle occupant Star Rating smoothed star (to clarify the view), after implementation of the countermeasures, of the road section A-431 (Córdoba province) in CGT Suroeste.

![Figure 15 Vehicle occupant Star Rating smoothed star "After"](https://vida.irap.org)

Source: https://vida.irap.org and DGT
FSI estimation: Vehicle occupant

The iRAP methodology also provides results for the fatality and serious injured (FSI) estimation before and after of countermeasure implementation, in percentile value.

Before countermeasure implementation:

The figure below shows the FSI estimation, before implementation of the countermeasures, of the road section A-4 (Córdoba province) in CGT Suroeste.

![Figure 16 FSI estimation “Before”](https://vida.irap.org)  
Source: https://vida.irap.org and DGT

After countermeasure implementation:

The figure below shows the FSI estimation, after implementation of the countermeasures, of the road section A-4 (Córdoba province) in CGT Suroeste.

![Figure 17 FSI estimation. After](https://vida.irap.org)  
Source: https://vida.irap.org and DGT
Predicted casualty reduction map (Total FSI saved per year)

Also, the results include the predicted casualty reduction map, in value per km. The figure shows the results in the traffic management centers of Norte and Suroeste.

![Predicted casualty reduction map](https://vida.irap.org)

**Figure 18 Predicted casualty reduction map**

Source: [vida.irap.org](https://vida.irap.org) and DGT

**Safer Roads Investment Plan**

An SRIP is a prioritized list of countermeasures (safety treatments) that can cost-effectively improve Star Ratings and reduce infrastructure-related risk. More than 90 road improvement options can be analyzed by the iRAP model to generate affordable and economically sound investment that improve a road's Star Ratings and, when implemented, can save lives.

Investment Plans are based on an economic analysis of a range of countermeasures, which is undertaken by comparing the cost of implementing the countermeasure with the reduction in crash costs that would result from its implementation. They contain extensive planning and engineering information such as road attribute records, countermeasure proposals and economic assessments for 100 meters segments of a road network.

In interpreting the results of an iRAP assessment, it is important to recognize that an Investment Plan is designed to provide a network-level assessment of risk and cost-effective countermeasures. For this reason, implementation of countermeasures identified in an Investment Plan will ideally include:

- Local examination of proposed countermeasures,
- Preliminary scheme investigation studies, and
- Detailed design and costing, final evaluation and construction.

Countermeasure example:

The next figure shows how to view a certain countermeasure proposed for a road section. It includes the cost, FSI (fatalities and serious injuries) saved, cost per FSI saved and BCR (>= 10 in this case).
The iRAP project “CGT Suroeste” was developed during the year 2019 and the first part of 2020. Therefore, the countermeasures haven’t yet been implemented. In this Safer Road Investment Plan, some countermeasures improve the road safety significantly like traffic calming, shoulder rumble strips or improvement of the curve delineation. However, to implement the different SRIP countermeasures, some difficulties have been found. Two cases are explained below:

- Central hatching is one of the most common countermeasures in SRIP from ViDA. Implementing this countermeasure in a long sequence of consecutive frames make impossible overtaking, so this situation could reduce the Level of Service (LoS) of the road.

- Central barrier. A common countermeasure for avoiding head on crashes is to place a central barrier. Thus, carriageways are separated and the associated risk goes down. However, the Spanish legislation establishes that it is possible to overtake a bicyclist even when a single continuous central line indicates overtaking ban (to overtake a bicyclist, driver must leave 1.5 meters away between both users). So, this measure will make impossible overtake a bicyclist and could reduce the Level of Service (LoS) of the section.

5.5 Comparison of crash databases and SRS results

In Spain, there are lot of data related to crash features and it is ordered and GPS located. However, as part of the iRAP model calibration, an estimate of the number of deaths and serious injuries that occur on the road was required. In order to allocate deaths and serious injuries to the network, the iRAP model requires an estimate of the distribution of deaths by road user type.

The number of fatalities, distribution by road user category, user crash type, ecc; are calculated
for the whole road network, all the road section included. The figure below shows the information required.

![Figure 20 Data on crashes required in iRAP](source: DGT)

So, the crash information when performing iRAP model is less detailed than the raw crash data.

The next figure shows the features available in the Spanish road management authority.

![Figure 21 Crash features available](source: DGT)

And it is stored in the ARENA II database.

![Figure 22 Crash database DGT](source: DGT)

Using a GIS analysis, it is simple to establish the areas were accidents are grouped together. So, DGT do not need to estimate the crash data in order to perform iRAP model calibration.

The figure below shows how data crash can be located in the network. Example of traffic management centre CGT Suroeste.
Taking into account the valuable and extensive crash dataset that road authorities have created, a precise and accurate solution could be to overlap, and analyse per each road section, the crash database and the SRS (iRAP results) to perform new plans and political decision making.

The idea is shown in the next figure.

5.6 Use case: Undivided carriageways in rural/open areas

One use case that can be performed using the road audit is to upload the crash rate in rural undivided carriageways. As it has been seen, 73% of fatalities in 2019 take place on this road type. However, this rate can increase if there is a common definition of “Undivided carriageways in rural/open areas”.

However, what is the definition of “Undivided carriageways in rural/open areas” in the Spanish legislation?

In the Spanish legislation, there are several definitions. The definition depends on the road authority in each case so it is difficult to estimate the total length of Undivided carriageways in rural/open areas if only the Spanish legislation is taken into account.

The criteria employed are using village sings and soil types.

A solution for this issue could be use the iRAP attributes in order to consolidate a unique definition of these road sections and then, update the crash data and make political decision to deal with this road risk.

This solution is shown in the scheme below.

**Figure 25 Different criteria to define a rural/open area**

Source: DGT

**Figure 26 Scheme of the use case**

Source: DGT

5.7 How Star Ratings and risk mapping can be incorporated to the Spanish Strategy?

The guideline is made a comparative between two road assessment techniques that use
different inputs (traffic volume, speed limit, traffic crashes, etc). The techniques are the SRS use by iRAP and the Risk Rate, use by EuroRAP. 

Both techniques use a color band to show the results.

---

**Star Ratings**

Methodology measures risk assessment for vehicle occupants, motorcyclists, pedestrians and bicyclists through infrastructure analysis.

SRS is calculated for each 100 meters segment of road for vehicles occupants, motorcyclists, pedestrians and bicyclists. These scores are then allocated to Star Rating bands to determine the SRS for each 100 meters of road. However, for the purposes of producing a road map, 100 meters is too much detail. Hence, Star Ratings are smoothed (or averaged) over longer lengths in order to produce more meaningful results.

<table>
<thead>
<tr>
<th>Star Rating band</th>
<th>Star Rating Score (SRS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>★</td>
<td>22.5+</td>
</tr>
<tr>
<td>★★</td>
<td>12.5 – &lt;22.5</td>
</tr>
<tr>
<td>★★★</td>
<td>5.0 – &lt;12.5</td>
</tr>
<tr>
<td>★★★★</td>
<td>2.5 – &lt;5.0</td>
</tr>
<tr>
<td>★★★★★</td>
<td>&lt;2.5</td>
</tr>
</tbody>
</table>

---

**Risk rate**

Is defined by the number of fatal and serious crashes in 3-year period for each 1.000 million vehicles-kilometre.

- Data section:
  - Road name.
  - Kilometre point (start and end)
  - Type of road (highway, etc)
- Traffic and crash data:
  - Annual average daily Traffic AADT (3 years)
  - Number of Fatal Crashes and Number of Serious Crashes (3 years)
  - Type of crash
- Characteristics of the section:
- Speed limit
- Whether roadway divided
- Type of junctions

The formula uses to calculate it, is the following:

\[
\text{Risk Rate}_{\text{period=3 years}} = \frac{\text{Number Fatal and Serious Accidents}_{\text{period}} * 10^9}{\text{Annual average daily Traffic AADT} * \text{Length} * 365 * \text{Period}}
\]

**Figure 29 Risk rate formula**
Source: DGT

Risk Rate is divided into five colored bands from low risk (green colour) to high-risk (black colour).

<table>
<thead>
<tr>
<th>Level</th>
<th>Risk Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.0&lt;Rate&lt;7.5</td>
</tr>
<tr>
<td>Low-medium</td>
<td>7.5&lt;Rate&lt;30.8</td>
</tr>
<tr>
<td>Medium</td>
<td>30.8&lt;Rate&lt;53</td>
</tr>
<tr>
<td>Medium-high</td>
<td>53&lt;Rate&lt;90</td>
</tr>
<tr>
<td>High</td>
<td>Rate&gt;90</td>
</tr>
</tbody>
</table>

**Figure 30 Risk rate bands**
Source: DGT

The next figure shows the results of the Spanish Risk Map during the period 2016-2018.

**Figure 31 Risk Spanish Map 2018**
Source: 16º Resultados del Estudio Eurorap. 2018. RACC

**Expected Results**

Comprehensive diagnosis that allows a problem approach from different angles (preventive diagnosis).

In order to have a classification of the road network that allows a prioritized analysis of the sections that present a greater problem.

This methodology will allow find differences between:
- Road with low stars and a low risk rate: Crash investigation at cluster sites, action and monitor.
- Road with low stars and high-risk rate: Road user behaviour, enforcement and vehicle safety improvements.
- Road with high stars and a low risk rate: Road engineering. Improvements are needed in order to prevent crashes occurring.
- Road with high stars and high-risk rate: Investigation and action needed immediately to improve road infrastructure.

Figure 32 Expected results integrating both methodologies
Source: iRAP Star Rating and Investment Plan Implementation Support Guide

6. Data analysis and reporting leading to Star Rating and Safer Roads Investment Plans (SRIP)

This subtask is intended to improve the translation of technical reports, using the Star Rating Score (SRS) and Safer Roads Investment Plans (SRIP), into political decisions.

The goal is to steer, according to evidence based on data, the allocation of road maintenance budget in the Spanish road network.

The subtask index is made up of: what is the thorough transformation towards political decisions, which are the difference between subjective and objective decision making -- what are the SRIPs, how is being the iRAP Spanish experience, what is the government strategy, what are the countermeasure to improve the road safety implemented by DGT and what are the difficulties to implement the SRIP in the Spanish road network?

6.1 Thorough transformation towards political decisions

The next scheme explains the steps to develop an iRAP project. The firsts steps are the road network selection followed by the road survey and coding work. After that, the results obtained are the SRS and the SRIP, and the last step is how to manage them and how to translate it into political decisions.
Subjective versus Objective decision making

At the beginning, investment plans to improve the road infrastructure were made in a completely subjective way and there were no objective criteria to prioritise the road sections. Later, some data was collected (such as crashes or vehicle flow) and the investment plans were developed according to reactive measures.

Now, by using road attributes, it is possible to perform a complete analysis that joins infrastructure features and external data, using the iRAP methodology, to create investment plans (SRIP) that set proactive measures that reduce fatalities and serious injuries.

These different investment plans approaches are explained in next figure:
6.2 Safer Roads Investment Plans

A Safer Roads Investment Plan recommends Benefit-Cost interventions to improve the Star Rating score and reduce the road risk related with the infrastructure.

SRIP are based on:
- Planning and engineering information such as road attribute records, countermeasure proposals and economic assessments for 100 m segments.
- Economic analysis of a range of countermeasures undertaken by comparing the cost of implementing the countermeasure with the reduction in crash costs that would result from its implementation.

The SRIP reports lists countermeasures options for the selected filters and search settings. Its description contains the following features:
- **Total FSIs Saved**: number of fatalities and serious injuries (FSIs) that could be prevented over the life of the plan after the countermeasures are built.
- **Total PV of Safety Benefits**: value of the crash cost savings over the life of the plan that could be realized if the countermeasures are built.
- **Estimated Cost**: value of the cost of building and maintaining the countermeasures over the life of the plan.
- **Cost per FSI Saved**: Cost of the countermeasures for each FSIs saved.
- **Program BCR**: the benefit cost ratio (BCR) is the Economic Benefit divided by the Cost. The BCR provides an indication of the value of money for the program. A BCR qualification value \( \geq 5.00 \) means that the benefits of all proposed countermeasures will be at least 5 times greater than the cost.
  - Common and pre-established BCR values are 3, 5 and 10.
- **Length / sites**: length of road in kilometers, or number of sites (locations), where the countermeasure(s) would be developed.

6.3 iRAP Spanish experience

During the period 2017 - 2018 was developed a pilot test in the North traffic management center (CGT Norte) about 3,001 km of road network and at the present time is been developing the second zone in the Southwest traffic management center (CGT Suroeste) about 3,266 km of road network.

<table>
<thead>
<tr>
<th>Traffic Management Center</th>
<th>Road IRAP network (km)</th>
<th>Period (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North (CGT Norte)</td>
<td>3,001</td>
<td>2017 - 2018</td>
</tr>
<tr>
<td>Southwest (CGT Suroeste)</td>
<td>3,266</td>
<td>2019 - 2020</td>
</tr>
<tr>
<td>Total</td>
<td>6,267</td>
<td></td>
</tr>
</tbody>
</table>

Source: DGT
The sum show that the total length road network is 6,267 km.

The following parts of the document, describe the results achieved during the iRAP Spanish experience, related with the SRS and the SRIPs.

**Star Ratings CGT Suroeste and CGT Norte**

The figure shows the Star Rating score smoothed star of vehicle occupant, before countermeasure implementation, of CGT Suroeste and Norte traffic management centers.

![Figure 35 Vehicle occupant Star Rating CGT Suroeste and CGT Norte](image)

Source: DGT by vida.irap.org

Apart from the SRS, other outcomes obtained has been the SRIPs of booth traffic management center areas.

**Safer Roads Investment Plan CGT Suroeste**

The following figure shows the SRIP of CGT Suroeste. The first column explains the type of countermeasure to develop.

Investing 31,193,599 € to upgrade the road infrastructure with a benefit cost ratio minimum of 3, the number of fatalities and serious injuries saved will be 778 and the final benefit cost ratio will be 7.

By default, the countermeasures are graded by the fatalities and serious injured saved; but also, is possible to graded them using other features.

The SRIP shows that the most important countermeasures, graded by the fatalities and serious injured saved, are to implement central median barrier (1+1), central hatching, additional lane (2+1 road with barrier) and shoulder rumble strips.
<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>Length / Sites</th>
<th>FSi saved</th>
<th>Total PV of Safety Benefits</th>
<th>Estimated Cost</th>
<th>Cost per FSI saved</th>
<th>Program BCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central median barrier (1+1)</td>
<td>67.00 km</td>
<td>240</td>
<td>206,121,608</td>
<td>31,193,590</td>
<td>40,090</td>
<td>7</td>
</tr>
<tr>
<td>Central hatching</td>
<td>90.40 km</td>
<td>208</td>
<td>55,219,955</td>
<td>5,838,029</td>
<td>26,092</td>
<td>10</td>
</tr>
<tr>
<td>Central median barrier (no duplication)</td>
<td>22.40 km</td>
<td>154</td>
<td>40,062,727</td>
<td>4,858,262</td>
<td>31,406</td>
<td>8</td>
</tr>
<tr>
<td>Additional lane (2 + 1 road with barrier)</td>
<td>1.90 km</td>
<td>36</td>
<td>5,111,359</td>
<td>2,995,000</td>
<td>72,273</td>
<td>4</td>
</tr>
<tr>
<td>Shoulder rumble strips</td>
<td>157.00 km</td>
<td>34</td>
<td>5,253,937</td>
<td>1,703,530</td>
<td>50,560</td>
<td>5</td>
</tr>
<tr>
<td>Traffic calming</td>
<td>21.00 km</td>
<td>27</td>
<td>7,137,545</td>
<td>742,618</td>
<td>27,562</td>
<td>10</td>
</tr>
<tr>
<td>Pedestrian fencing</td>
<td>23.10 km</td>
<td>20</td>
<td>5,196,308</td>
<td>226,261</td>
<td>11,350</td>
<td>23</td>
</tr>
<tr>
<td>Road sign provision passenger side (inform. path)</td>
<td>41.90 km</td>
<td>16</td>
<td>4,076,040</td>
<td>1,905,557</td>
<td>65,717</td>
<td>4</td>
</tr>
<tr>
<td>Street lighting (mid-block)</td>
<td>6.70 km</td>
<td>15</td>
<td>3,899,801</td>
<td>958,800</td>
<td>65,135</td>
<td>4</td>
</tr>
<tr>
<td>Central line marking / flimsy posts</td>
<td>32.40 km</td>
<td>9</td>
<td>2,363,281</td>
<td>333,125</td>
<td>29,067</td>
<td>7</td>
</tr>
<tr>
<td>Improve curve delineation</td>
<td>12.70 km</td>
<td>4</td>
<td>1,161,582</td>
<td>272,481</td>
<td>60,883</td>
<td>4</td>
</tr>
<tr>
<td>Road sign provision passenger side (adjacent to road)</td>
<td>1.30 km</td>
<td>2</td>
<td>470,520</td>
<td>196,948</td>
<td>88,363</td>
<td>3</td>
</tr>
<tr>
<td>Street lighting (intersection)</td>
<td>3 sites</td>
<td>2</td>
<td>458,748</td>
<td>100,000</td>
<td>62,266</td>
<td>4</td>
</tr>
<tr>
<td>Median barriers - passenger side</td>
<td>0.40 km</td>
<td>1</td>
<td>162,457</td>
<td>55,500</td>
<td>90,500</td>
<td>3</td>
</tr>
<tr>
<td>Improve curve delineation</td>
<td>2.30 km</td>
<td>1</td>
<td>354,155</td>
<td>47,244</td>
<td>33,333</td>
<td>7</td>
</tr>
<tr>
<td>Footpath provision passenger side (adjacent to road)</td>
<td>0.20 km</td>
<td>1</td>
<td>146,217</td>
<td>46,990</td>
<td>33,057</td>
<td>2</td>
</tr>
<tr>
<td>Footpath provision passenger side (&gt;3m from road)</td>
<td>0.40 km</td>
<td>1</td>
<td>138,462</td>
<td>53,992</td>
<td>102,532</td>
<td>3</td>
</tr>
<tr>
<td>Footpath provision driver side (inform. path + m)</td>
<td>0.70 km</td>
<td>1</td>
<td>137,070</td>
<td>55,950</td>
<td>105,811</td>
<td>3</td>
</tr>
<tr>
<td>Detection and giving (intersection)</td>
<td>8 sites</td>
<td>1</td>
<td>372,779</td>
<td>102,776</td>
<td>73,055</td>
<td>4</td>
</tr>
<tr>
<td>Sign detection (information removal)</td>
<td>0.70 km</td>
<td>1</td>
<td>263,469</td>
<td>29,490</td>
<td>23,626</td>
<td>11</td>
</tr>
<tr>
<td>Parking improvements</td>
<td>1.00 km</td>
<td>0</td>
<td>75,607</td>
<td>15,290</td>
<td>51,427</td>
<td>5</td>
</tr>
<tr>
<td>Upgrade pedestrian facility quality</td>
<td>1 sites</td>
<td>0</td>
<td>43,740</td>
<td>31,913</td>
<td>132,106</td>
<td>2</td>
</tr>
<tr>
<td>Wide carriageway</td>
<td>0.50 km</td>
<td>0</td>
<td>6,688</td>
<td>2,211</td>
<td>82,671</td>
<td>8</td>
</tr>
</tbody>
</table>

**Figure 36 Safer roads investment plan of CGT Suroeste**

Source: DGT by vida.irap.org

**Safer Roads Investment Plan CGT Norte**

The figure shows and example of a technical report of the Valladolid province (CGT Norte) developed by DGT subcontractors’ companies CPS and RACC. This iRAP project was developed during the 2017 and 2018.
This technical report included, for the road network of Valladolid province analysis, the Star Rating score for all users (vehicle occupants, motorcyclist, bicyclist and pedestrian), the SRIP to improve road safety, and explanation of how the Star Rating score would be after implementing the countermeasures.

6.4 Government Strategy

The government strategy consists of showing how the Star Rating score is a useful tool to assess road infrastructure upgrades, using the following guidelines.

The first guideline is to transfer (publish, communicate and advise) the results of the iRAP project (technical reports) to other administrations not included in the SLAIN Project, such as to:

- National government
  - Ministry of Transport, Mobility and Urban Agenda
- Others governments
  - Regions
  - Provinces
  - Councils

The second guideline is to use different Benefits-Cost Ratio and Safer Roads Investment Plan for each road Spanish authority, because each one has different road types, road safety problems and fatalities types.

This action will show specific and different countermeasure proposal for each road authority depending on the budget available and the BCR that can be reached. These are judged individually because it could be possible that some countermeasure would save more fatalities and severe injuries than other countermeasures.

Additionally, these changes will allow a new SRS to be calculated for each authority, after implementation of the specific countermeasure. Also, it will be possible to select the countermeasures based on the targets and resources available by each road authority.

The work scheme bellow shows the approach of this methodology and the different steps to implement it.
The third guideline is to classify the road sections, before implementing the SRIP, according to their characteristics. Furthermore, of the classification included in iRAP such as:

- Carriageway label (divided or undivided),
- Area type (urban or rural),
- Property access point (commercial, residential, etc),
- Land use (educational, commercial, industrial, undeveloped areas, etc),
- Traffic flow;

the idea is to use more characteristics of the road section, such as:

- Access roads: transition section between urban and rural area type.
- High number of intersections (roundabouts, 3-leg, 4-leg, etc).

And the last guideline is to classify the countermeasures depending on the road section typology.

E.g.: Last year, DGT in coordination with all Spanish road’s authorities, reduced the speed limit on undivided carriageway roads with more than 7 meters of wide, from 100 km/h to 90 km/h.

### 6.5 Further analysis: Why we score and what we score?

As part of the work done within task 2, an additional analysis is foreseen in order to see how Risk Mapping and Star Rating are related.

Taking into consideration a particular area, for instance Catalonia, it should be possible to find a relation between the results obtained in the Risk Mapping and the results obtained in the Star Rating.
The main objectives of this study are:
To better understand the information comprised in both maps through an Explanatory Data Analysis (EDA).
To detect and explain extreme values, anomalies, specific behaviours, etc.
To find a relationship between the Star Rating and the Risk Mapping in order to be capable to predict or estimate how the KSI rate can be reduced if the SRS score is increased.
To suggest improvements for the future models.

The methodology designed to elaborate this study is comprised by the following 4 steps:

1. **Preparation of the datasets.** First of all, it is needed to prepare the original datasets used to elaborate the maps in order to be "joinable" between them.
2. **Creation of a new dataset.** Secondly, it is necessary to join both datasets to make some preliminary explorations to observe possible relations, anomalies, etc.
   a. This new dataset should have the road name, kilometric point, SRS values, KSI rate and other relevant variables like crash data, average daily traffic intensity, etc.
   b. The length of the sections aggregated in this new dataset may be different from the original ones.
3. **Correlation model.** Create a new model to correlate the risk rate and the star score using the variable introduced in the new dataset.
4. **Validation.** In order to validate the model, it is foreseen to include more data from other regions or countries.

The results obtained in this analysis will be presented in the next deliverable D2.4.
Conclusions and achieved goals

The present deliverable explains how the EuroRAP applications and policy formulation have been improved thanks to the Spanish experiences in road safety projects during the last years and the different ways to tailor the methodology to national and regional needs. The document has been structured in six different chapters representing the different subtasks of the project, with the involvement of one or several Spanish participants:

**Subtask 2.8.1. Define final objectives of Star Ratings:** RACC-ACASA and TES developed several EuroRAP projects in Catalonia with the first experiences in Star Ratings and Safer Roads Investment Plans in that region. Hence, the methodology has been tested and at this stage a further step has been developed to define the final objectives of the EuroRAP methodology. After a detailed analysis of RACC data and after a wide analysis of the staff performance of TES in terms of conservation and maintenance, the results will be incorporated to the existing road maintenance and a monitoring protocols will be deployed by the public administration. The strategy will be focused in two ways:

- Combine all the data that TES has in the different management systems from all the territory, obtain accurate conclusions about what is happening in the road network and therefore make evidence-based decisions when investing the conservation budget in road countermeasures, using RACC’s Safer Roads Investment Plans.

- Perform the cost-benefit analysis of conservation operations, in terms of road safety and not only within the scope of each management system associated with specific risks. The planning of the maintenance work will be conducted more efficiently and will obtain the best combination of personal work and external contracts.

The final objectives above have been developed in the SLAIN framework and therefore all of them can be replicated in other countries.

**Subtask 2.8.2. Country strategy:** With the RACC-ACASA’s data management, the Spanish public administrations have defined their strategy on data collection: DGT has developed specific methodologies for obtaining supporting data inputs required in an EuroRAP project: value of life, annual average daily traffic, countermeasure cost, type of crashes and operating speed. On the other side, TES from the Catalan government is working on developing an automated coding for obtaining the information (all parameters required by the methodology) and avoiding human errors during the process. Hence, the country strategy of Spain is covering all the Star Ratings methodology: the collection of external data and coding of road attributes. RACC-ACASA has contributed with the strategy definition and will continue the contribution assessing the implementation of a systematic collection protocols.

DGT has classified the Spanish actors according to the road authorities, traffic management centers and other stakeholders. 93 countermeasures have been defined by DGT to be used as a basis for Spanish Safer Roads Investment Plans and a how to collect all supporting date has been reported.

**Subtask 2.8.3. Training on road survey and road coding for Star Ratings:** RACC-ACASA has developed a training course about the first steps of EuroRAP methodology: “road survey for data collection and road coding to process all the information from the infrastructure”. All the contents of the training are included and, in general terms, are divided in the following aspects:
- Road survey: detailed information of the field work and all devices of the equipped vehicle and its calibration, the selection of road segments/routing and how to conduct surveys and data collection process every 10m.

- Road coding: how to code the images collected during the inspections and the back-office process to obtain all the 52 road attributes. In addition, the characteristics of the output file to calculate the road safety action plan are analysed in the training documents.

- Supporting data: which type of additional data from other sources is needed: traffic volumes (AADT), crash data (location, types, modes, fatal and serious victims, etc) on the road network under study, operation speed (V85 percentile) and costs of countermeasures.

DGT and its subcontractors will be trained to be capable of creating road surveys and all coding process according to EuroRAP manuals.

**Subtask 2.8.4. Training on ViDA software:** RACC-ACASA has also developed a training on use of settings of the ViDA tool, especially on Star Ratings for each mode of transport and Safer Roads Investment Plans with different benefit/cost ratios. Both are part of a systematic, proactive approach to road infrastructure risk assessment and renewal based on research about where severe crashes are likely to occur and how they can be prevented.

- Star Ratings: the objective is to measure the safety performance of a road network. The 52 road attributes coded (see subtask 2.8.3) are scored (from 1 to 5 stars) and combined to reflect the overall safety of car occupants, motorcyclists, bicyclists and pedestrians. The ViDA online simulator is a key aspect of the training.

- Safer Roads Investment Plans: the main goal is to know how EuroRAP algorithm estimates the number of killed and seriously injured persons (KSI) and the display of countermeasures for reducing casualties. The different periods of time and cost-benefit ratios are key aspects of the training.

The DGT and its subcontractors will be trained to understand how to calculate both results of the EuroRAP methodology. In addition, they will also receive all the indication to maintain both Star Ratings and Safer Roads Investment Plans updated with road infrastructure modifications.

**Subtask 2.8.5. Analysis Assess final results from Star Ratings and Safer Roads Investment Plans:** In order to validate that EuroRAP results are useful for assessing the road infrastructure upgrades, RACC-ACASA and DGT went one step before and developed a criteria to select the road network to be assessed based on crash rates, road authorities (owners) and with AADT>2,000 vehicles/day. In addition, the Spanish TEN-T network has been widely analysed: firstly developing a benchmarking to know the TEN-T network available data and secondly to know the results.

With this information, DGT studied the ways to proceed considering the relationship between Star Ratings and Risk mapping:

- Road with low stars and a low risk rate: Crash investigation at cluster sites, action and monitor.
- Road with low stars and high-risk rate: Road user behaviour, enforcement and vehicle safety improvements.
- Road with high stars and a low risk rate: Road engineering. Improvements are needed in order to prevent crashes occurring.
- Road with high stars and high-risk rate: Investigation and action needed immediately to improve road infrastructure.

DGT has led an assessment of the application of the iRAP tools suggesting some improvements on iRAP methodology based on its own SRIP country experience.

**Subtask 2.8.6. Data analysis and reporting leading to Star Rating and Safer Roads Investment Plans:** This subtask was developed by DGT with the objectives to take advantage of the Star Ratings results and Safer Roads Investment Plans, as a natural continuation of the methodology and the task. DGT’s objective is to improve the translation of technical reports into political decisions to effectively improve road network and make roads safer. The subtask focused on the use of evidence-based results and by the allocation of road maintenance budget. The document shows one step further with what the specific countermeasures to improve the road safety currently are implemented in Spain and what are the difficulties to deploy the SRIP in the Spanish road network. This information from the public information and based on proven experience will be very valuable for developing road safety strategies in other countries in the SLAIN framework.

**References**

- Accident rate report 2019. DGT
- Spanish national government web page
- Google Street View
- Road safety in Spain: “Measures for safer roads”. DGT
- Ministerio de Fomento
- Eurostat
- ViDA - IRAP
- 16º Resultados del Estudio EuroRAP. 2018. RACC
- 17º Resultados del Estudio EuroRAP. 2019. RACC
- iRAP Star Rating and Investment Plan Implementation Support Guide
Appendix A: The Spanish case approach: Descriptions and examples of the coding.
In order to share common data and implementation of best practices and standards, in January 2019 the International Road Assessment Programme workshop was held in Madrid at DGT Headquarters. The workshop meeting allowed to compare experiences and solve doubts and issues related to the coding in Spain.

Furthermore, common criteria were defined among different DGT work teams and specific cases were discussed in order to adapt the Star Rating Coding Manual to the Spanish case. These cases can be grouped into the following points:

- Median type
- Roadside severity
- Speed management
- Vehicle parking
- Specific cases

**Median type**

Median type within undivided roads must be coded as “Centre line” by default. However, overtaking ban central line is widely extended over Spanish undivided roads.

![Figure 40 Median type](source: Google Street View)

It is suggested that, in these cases, the overtaking ban stretch of road by mean of horizontal road signs should be register as “wide central line (0.3m – 1m)”. According to the new criteria, the Star Rating Score (SRS) would change, as it can be seen in the following picture:
It is important to point out that this compromise solution is included in the Road Coding Manual 2019.

**Roadside severity**

First of all, it is important to point that trees and non-frangible poles (greater than 10cm diameter) are usually located at each side of undivided road sections throughout Spain.

Both items are considered equivalent in the iRAP methodology, so the influence of these items in the Star Rating is the same. Therefore, both rank equal to perform the calculation of Star Rating score.
On the other hand, it is common to find vertical road signs supported by two or more poles. Collisions with those objects could potentially result in serious injury to a road user upon impact, those signs might be codified as non-frangible poles greater than 10cm diameter.

However, as the pole diameter is usually less than 10cm, those should not be coded. Therefore, if the sign is not coded, the Star Rating Score is better (lower) and the SRIP (Star Rating Investment Plans) does not record the presence of these signs as a hazard.
Moreover, in Spain, “fish-tail terminals” have been deeply committed in order to solve road safety problems. For that purpose, the safety barrier-metal ends buried in the ground. Nevertheless, these solutions may not be reflected adequately in the coding process.

Consequently, Spanish authorities set up measures for solving problems but those are not reflected in the SRS (if a measure solve road safety problems, SRS should be lower).

Additionally, it is common to find established buildings close to the lane in urban or rural town, or village area types. Collisions with these buildings could result in serious injury to a road user upon impact, those buildings be registered as “rigid structure/bridge or semi-rigid structure”.

![Figure 46 Barrier-metal ends buried in the ground and end of metal safety barrier: “fish-tail terminals”](source: DGT by vida.irap.org)

![Figure 47 SRS: Driver and passenger side safety-barrier metal coded in a certain road section (frame)](source: DGT by vida.irap.org)
The main importance between rigid and semi-rigids structures when a building is presented into a frame is the position of the building. Two cases must be considered:

1. If there is a building corner into the frame (as it can be seen in the picture above), it must be coded as rigid structure.

2. It is suggested that if the building wall or a continuous line with several buildings is set in parallel with carriageway lanes, then the observed structure could be coded as a semi-rigid structure to reflect the reduced risk caused by the likely deflection of the vehicle in the crash.

These cases affect the final Star Rating Score, as can be seen in the following picture:

![SRS: Driver and passenger side semi-rigid structure](image)

Finally, there are several Spanish road stretches where it is common to find a wire barrier near to the lane in order to fence farms.
Fences were coded as semi-rigid structure (roadside severity – driver-side object). However, in the workshop meeting in Madrid, the iRAP instructor suggested that it must be coded as “No object” because they may not noticeably impede the travel of a vehicle. Particular examples will be considered further.

If it is coded as “no object”, the SRS is lower. (It is important to take into account that if an object (pole, tree, building, etc.) is located behind the fences, the object must be coded and the SRS will change).

**Speed management**

In Spain, it is common to set speed tables in order to manage the speed limits. Nevertheless, these solutions may not be fully reflected in the coding process other than as “traffic calming”.

Consequently, Spanish authorities who have set up measures for solving problems but those may not be fully reflected in the SRS (if a measure solve road safety problems, SRS should be lower).
Vehicle parking

It is suggested that vehicle parking, even vehicle illegally parking, should be recorded where at least one of these two situations is observed:

1. There are several vehicles parked along the side of the road.
2. There is an area along the side of the road where vehicles are often parked on.

Specific cases

A special case in the coding process is the presence of a bridge parapet into a frame. As this barrier type is not explicitly defined in iRAP, it is necessary to adopt a compromise solution because the bridge parapet is not a concrete barrier or a metallic barrier.
In the framework of an overall compromise, for coding the bridge zone frames two criteria were adopted:

1. Frame before the bridge: Safety barrier-metal.
2. Frame in the bridge section: semi-rigid structure or building.

When a pedestrian crossing facility passes parallel to main lanes, it must be coded as an intersection as well. According to the Start Rating Coding Manual, it is required to codify the frame as 3 leg with no protected turn lane and unsignalized marked crossing without protection.

![Intersection coding](image)

Figure 54 Intersection coding
Source: Start Rating Coding Manual

Therefore, intersection type, intersection quality and vehicle intersection flow must be defined.

Finally, it is important to point out that nowadays, ViDA platform does not accept coding properly access point and pedestrian crossing facilities in the frame. In Spain, it is common to find these situations in commercial accesses and the adopted solutions are described below:

![Intersection coding](image)

Figure 55 Intersection coding
Source: Start Rating Coding Manual

However, this coding situation is not accepted in the online software platform ViDA. Therefore, when this situation is observed there are two different points to take into account:

1. When the observed access point could be affected by high AADT, it is coded as an intersection (intersection type, quality and flow is estimated). Then, it is possible to code the pedestrian crossing facilities (intersection road).
2. When the AADT of the observed access point is negligible, the frame will be coded as property access point but it will not code as pedestrian crossing facilities.
How to adjust DGT countermeasures to SRIP in Spain

DGT invest in the improvement of the network road safety, with special attention to the vulnerable users as bicyclist and pedestrians.

Theoretically, all countermeasures to improve the road safety carried out by DGT should be coded in iRAP project for reducing the SRS, because the target of the implementation is to reduce the road safety risk.

This section clarifies how to code the countermeasures taken to improve road safety in the iRAP project once the improvement plans have been made, in other words, once executed the SRIP.

Some of these can be coded. e.g.: speed limit changes, lane width modifications, overtaking ban, centerline rumble strips and guide of countermeasures for cross town-link.

But because iRAP surveys reflect a situation at a particular point in time, there are countermeasures that apparently do not have an accurate coding attribute. e.g.:

- Speed limit adjustable: depending on traffic conditions and installed on a variable message panel.

![Figure 56 Speed limit adjustable](image)

Source: Road safety in Spain: “Measures for safer roads”. DGT

It may be appropriate to codify the countermeasure like an existing traffic calming attribute.

- Smart intersection: detect in a three-leg intersection the presence of another vehicle and previously notify the drivers.

![Figure 57 Smart intersection](image)

Source: Road safety in Spain: “Measures for safer roads”. DGT
It would also be interesting to codify this countermeasure as an existing traffic calming attribute.

- Safer routes for cyclist: speed limitation during weekend mornings in a frequently used routes by cyclist.

![Figure 58 Safer routes for cyclist](source)

Source: Road safety in Spain: “Measures for safer roads”. DGT

It may be appropriate to codify the countermeasure as a lower speed limit attribute.

- Advisory Speed Limit: Recommended speed signs are not registered in the iRAP methodology. The Coding Manual specifies that these signs must not be codified during the road audit.

![Figure 59 Example of Advisory Speed Limit](source)

Source: Google Street View
It may be appropriate to codify these advisory signs (not road works signs) as a lower speed limit attribute.

**Difficulties in implementing different countermeasure in Spain**

There are some countermeasures in the SRIP that are difficult to implement them in the Spanish road network.

- **Central Hatching**
  The central hatching countermeasure is one of the most common in the single carriageway roads in the SRIP.
  This countermeasure could be difficult to implement it in a long sequence of frames because would make overtaking impossible, and could reduce the Level of Service (LoS) of the road section.
  The following figure shows a single carriageway section where it could be possible to implement this countermeasure analysing other factors.

  ![Figure 60 Example of single carriageway road](Source: Google Street View)

- **Central barrier (1+1)**
  Another common countermeasure for avoiding head on crashes is to place a central median barrier. Thus, carriageways are separated and the associated risk goes down.
  However, the Spanish traffic legislation (Law RDL 6/2015, about Motor vehicle traffic and road safety) establishes that it is possible to overtake a bicyclist even when a single continuous central line indicates overtaking ban and the driver must leave 1.5 meters away from the bicyclist. So, this countermeasure will make impossible overtake a bicyclist but it is permitted by the legislation and will reduce the LoS of the road section.
  The described situation is shown in the figure below.

  ![Figure 61 Legislation about meters away between driver and bicyclist](Source: Spanish national government web page and DGT)