SIXTH FRAMEWORK PROGRAMME
PRIORITY 1.6. Sustainable Development, Global Change and Ecosystem
1.6.2: Sustainable Surface Transport

SEROES – Best Practice in Road Safety Measures

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Executive Summary

One aim of this research project is to provide a freely accessible database for road authorities responsible for secondary roads, containing the Best Practice Safety Information Expert System. As a result SEROES has been developed.

SEROES the Secondary Roads Expert System is a web-based tool, freely accessible for everybody which comprises the possibility to be enlarged.

In that context best practice information about road safety improvement from the EU-member states and a worldwide background has been collected, examined and synthesised.

Building on that framework and based on the Handbook of Road Safety Measures by Elvik and Vaa\(^{1}\) the Best Practice Safety Information Expert System SEROES has been developed and implemented.

The application is structured into various menus for users and an additional menu for administrators. SEROES is a tool with low accident and road data requirements. The user only needs the incident site, accident type and the cause of the accident as input describing that way an existing road safety problem. Then the application offers several solutions, a cost-range and information about the effect for each of the provided measures. For a better understanding a user manual has been developed.

In a further step SEROES has been demonstrated together with the DST (Decision Support Safety Tool) (WP 11 and 12) in three countries: Turkey, Poland and the Netherlands. The demonstration of SEROES was integrated in the demonstration programme of the DST in WP12. It was carried out using a questionnaire (annex 1). The questionnaires have been evaluated and a summary of the comments and suggestions of the users has been elaborated.

Even if after the demonstration and several practical tests some fields of improvement have been identified, it can be said that by and large the users' impression of SEROES was positive.
1. Introduction

This report is addressed to local road authorities who are often confronted with road safety problems and the dilemma of not knowing exactly what is the effect of applying a certain measure.

Researchers from all over the word try to find and prove relationships between design parameters of roads and accident occurrence since years nevertheless this report concentrates above all on the most recent information available.

The objective of WP 9 was the development of a Best Practice Safety Information Expert System, based on an inventory of best practice information about road safety improvement. The Best Practice Safety Information Expert System was called SEROES. SEROES focuses on secondary road safety which is merely qualitative in nature. The application could be used as a source of recommendations for safety auditors or safety inspections.

WP9 provides an free-accessible on-line application for road authorities responsible for secondary roads containing the Best Practice Safety Information Expert System SEROES.

The first part of the report is based on a literature review about secondary road safety improvement information from the EU member states and an international background.

The authors focused on studies that relate secondary road geometry and intersection data with accident occurrence and severity. Special emphasis was also placed on other elements that have a possible influence on secondary road safety. Those elements are among others the roadside environment and the influence of speed on safety.

It was primary dealt with studies that relate road safety relevant elements in a quantitative way with accident occurrence but mentions also other research work which describes this relation in a rather qualitative manner.

Furthermore the document makes recommendations on secondary road and roadside design based on experience and best practice.

In the present document the term secondary roads (hereinafter often referred to as “roads”) refers to paved, single carriageway, two lane roads that are generally located outside urban areas."

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The second part focuses on SEROES the Secondary Roads Expert System. SEROES is an online application based on research work regarding the effect of road safety measures.

After the implementation the application has been demonstrated and evaluated in several European countries. A synthesis of the results is of the demonstrators is shown in the latter part of this deliverable.
2. Road Design and Operation Parameters and their effect

Road Safety

Using predominantly European sources, safety information of geometrical and other road design parameters as well as information about intersections has been gathered and analysed. A summary of the results of this analysis is shown in the subsequent chapter. The partners of WP 9, all very experienced in the field of road safety consider this information as Best Practice. The information used in SEROES includes a number of different effects on road accidents, not all of them best practice but it has been decided to mention also those practices and measure which in the past have turned out to be less effective than others just to give the user the possibility to compare them between each other and to detect also those measures that are counterproductive.

2.1. Geometry

In all European countries standards are the most important design tools.

For this reason the engineer should take into account the following recommendations, which are often not represented in the national road design standards:

− Avoid an irregular geometry in one single stretch with isolated curves, which suddenly restricts the operational speed

− Install additional lanes on steep gradients, to allow the overtaking of heavy vehicles

− Appropriate design of at-grade intersections or emplacement with grade separated intersections

− Restrict zones with successive vertical curves with ban of overtaking

− In roads with pronounced distended gradients, provide emergency lanes for heavy vehicles out of control

− Provide on the roadside an obstacle free zone, which is free of lateral dangers as masts, trees and bushes with trunks bigger than 1 m, subsurface drainage structures, pronounced berms (slopes of more than 4:1) and other fixed objects or conditions which could result dangerous. The width of this obstacle free zone
should be consistent with the geometric design, the operational speed and the traffic composition

2.1.1. Cross section

In the past years many road safety investigators tried to relate characteristics of cross section elements with accident frequency and/or severity. Due to a lack of sufficient data to conduct before-after studies, most investigators made use of statistical analysis, using regression models.

Because of the magnitude of possible influences, it is quite difficult to isolate the feature that was responsible for an accident. For this reason the results of these studies are not always satisfying – often they are contradictory. It is also hard to believe that one can apply with confidence conclusions based on data from one region to another region without adjusting them. Despite of the fact that investigators didn’t find the universal formula to predict accidents in dependence on characteristics of cross section elements, there are a number of promising approaches and recommendations.

Another important point concerning the effect of cross section characteristics on accident frequency and severity is the analysed accident type. By focusing just on the total number of accidents it may not be possible to unequivocally detect the effect of a certain feature (or change). The results of a study would be easier to interpret if researchers would always concentrate only on the key accidents related to a certain change.

More and more investigators take heed of this relation, thus one can observe an increasing accuracy of the results, although often they are still rather qualitative than quantitative.

The reduction of accident frequency when using wider lanes can be explained above all by the fact that drivers are able to regain control over their vehicles in case they left the road. Another advantage is the larger separation between opposite traffic flows, which is favourable regarding opposite direction head-on and opposite direction sideswipe accidents.

For lanes wider than 3,70 m can be said that they do not contribute any advantage regarding safety.Only for roads with an extremely high ratio of heavy vehicles such lane widths are appropriate.
Such wide lanes can be even be counteractive, due to the fact that they animate drives to dangerous actions, as overtaking in spite of oncoming traffic.

Palm and Schmidt conducted in 1999 a study to evaluate the influence of different standardised cross-section widths on road safety for single-carriageway roads outside urban areas in Germany. IV

What can be concluded from Palm/Schmidt’s study is that accident rate and severity increase on roads wider than an optimal width.

Just a few investigators tried to focus their studies on an optimum lane or carriageway width. (most researchers found a linear relationship) For this reason the optimal lane width cannot be defined ultimately.

Shoulders serve road users with an emergency to park their vehicles on them but they are also required to get vehicles that got beyond control back on the road.

It seems that the accident frequency decreases, when the shoulder width increases. This tendency can be observed for shoulder widths up to 3,00m. For roads that don’t have but will be equipped with shoulders, 1,50m seems to be the optimal width.III

HedmenV found an accident reduction when incrementing shoulders from 0,00 to 2,00 m but little additional benefit when incrementing the shoulder by more than 2,50 m.

As described previously most model types, due to its continuous form, doesn’t take an optimum shoulder width into account. This would only be possible with a model type that uses a U-shaped curve form to represent a potential increase in accidents beyond a certain shoulder width.

As mentioned above accident frequency and severity not only depend on one single cross section element, but on a combination of characteristics of these elements.

Therefore the lane width should be harmonised with the shoulder width. It doesn’t make sense to equip rather small lanes with large shoulders, because road user would use the shoulder to drive on it.

Extended no passing zones at single carriageway roads with slower vehicles can lead to congestion and consequently to accidents when passing.

The oncoming traffic limits the passing opportunities at roads with high traffic volume. If the terrain is additionally mountainous the sight distances can be too short to make the decision to overtake. Under those circumstances the disposal of slow/fast lanes
can be most effective when one talks about improving traffic operations, breaking up tailbacks and reducing delays caused by inadequate passing opportunities over larger stretches.

The more pronounced the gradient the more important and beneficial is the slow/fast lane.

Various studies indicate that slow/fast lanes at pronounced gradients reduce accident frequency by 10 to 40%.\textsuperscript{V,VI} The reduction often extends over the end of the widened stretch, which indicates that drivers have less pressure to overtake slower vehicles. Furthermore it can extend over the beginning of the stretch by the installation of indicative traffic signs about 2 to 5 km before the widened section.

Usually it is better to provide several shorter passing lanes than few larger. For example for a road with $v_{\text{Project}} = 100 \text{ km/h}$ the minimum length should be 600 m, the maximum length 1200 m and the lengths of the transition sections should be 250 m each.\textsuperscript{VII}

Medians are used to separate traffic from opposite directions. There are various types of medians for secondary roads:

- Narrow medians with physical barrier [metal or concrete] (if a vehicle hits the barrier it will returns to the flow of its own direction; makes it more difficult for pedestrians to cross the road where they shouldn’t)

- Narrow medians without physical barrier (optical separation of opposite traffics, doesn’t help the driver to recover control; lets pedestrians the possibility to cross the road in two stages)\textsuperscript{VIII}

Medians have a very positive effect on road safety, due to the separation of opposite traffics and they contribute some advantages to pedestrians. There are studies that prove that medians, which separate opposite traffics physically, would reduce accident frequency and severity, compared to other median types.

To maximise the safety effect, the number of gaps in the median should be minimised. The fewer apertures, the safer is the road. Studies show that with a narrow median with physical barrier the number of accidents probably increases, but the accidents will be less grave.
2.1.2. Horizontal alignment

Under the variables that influence in the elected speed the horizontal curvature is a deciding one, especially at speeds below 100 km/h.

From this it follows that one should play special attention on horizontal design, in particular on the uniformity of the horizontal alignment.

The consistency of horizontal alignment is an important point regarding road safety and for that reason road designer have to intent to provide elements that are consistent with what drivers expect based on their experience on similar roadways and on previous sections of a particular roadway.

To keep driver workload at a moderate level large differences and abrupt changes in horizontal alignment should be avoided. Major changes in driver workload requirements often lead to accidents. For safety reasons, the horizontal alignment must be consistent in terms of sight distances. This will also preserve the design speed of the roadway. Independent design of these features tends to increase accident potential. [IX]

For example an isolated closed curve in a road of long straight alignments is likely to be dangerous but the same curve in road of lower geometric standard wouldn’t generate problems. The first curve of a series could be more dangerous than the following curves.

Special control is required where:

\[ v_{85} \geq v_{\text{Project}} + 10 \text{ to } 15 \text{ km/h} \]

On sites where this occurs one should take alerting measures as:

- Extensive use of traffic signs
- Other measures that improve the drives visual perception.

The experiences show, that in cases where one does not meet the drivers expectations an important number of accidents can be generated.

Potential accident generators amongst others are:

- Long straight alignments followed by a isolated closed curve
- Curves in the same sense where the first is a light one and the second is very pronounced
2.1.3. **Vertical alignment**

Pronounced gradients are often associated with higher accident frequency. Regardless whether the gradient is ascending or descending can be said that the more pronounced the gradient the more frequent and severe are the accidents.

Studies show that due to heavy vehicle accidents descending gradients are more problematical but in general can be said that where the climatic conditions are disadvantageous all types of gradients are potentially problematical.

The length and the extend of gradients on secondary roads must be such that large speed differences between trucks and cars will not occur and that there will not be no important capacity reductions on the specific road.

In most countries the maximum gradient is specified in national design standards.

The maximum allowed gradient is determined considering road- and traffic characteristics like design speed, the length of the gradient the horizontal alignment, the presence of junctions and the traffic density and composition.

The maximum normative gradient will first be determined by the design speed. In the Netherlands for example they use the following table (maximum and desirable gradient):

<table>
<thead>
<tr>
<th>Gradient</th>
<th>Speed (km/h)</th>
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<tbody>
<tr>
<td></td>
<td>100 km/h</td>
</tr>
<tr>
<td>Desirable</td>
<td>4%</td>
</tr>
<tr>
<td>Maximum</td>
<td>5%</td>
</tr>
</tbody>
</table>

Table 1. Gradients in the Netherlands according to Handbook Road Safety

Vertical alignment is influenced by sight distance criteria, the topography of the roadway, and the designer’s need to meet ancillary goals (e.g., balancing excavation and fill quantities).

Vertical curves are designed to provide smooth transitions between tangent gradients. The ideal design of these features provides adequate sight distance via big enough vertical curve radii to allow for stopping once a driver has detected an object in the travel lane. This goal is often hard to meet because the terrain does not always allow for economical provision of safe and recommended sight distances. Especially crests (convex curves) often deal with problems that have to do with sight distance deficiency.
Sag curves (concave) are not considered to be very problematical regarding accident occurrence, except in nocturnal conditions.

Differences in height should be overcome by vertical curves and not with long gradients. The radius of a crest will generally be determined by the desired sight distance, while the bottom of the curve (or sag curve) will generally be determined by the desired stopping sight distance in nocturnal conditions. From the traffic safety point of view it is recommended to dimension a crest using the necessary passing sight distance. In practice it is often not possible to realize this recommendation, but than it will be enough to dimension using the stopping sight distance.

2.1.4. Coordination between horizontal and vertical alignment

The complexity of the geometry makes the interaction of horizontal and vertical alignment the least studied aspect of geometric design. Normally, horizontal and vertical alignments are designed separately to meet certain criteria and then brought together, assuming that design consistency will be maintained. IX

One should focus special attention on the relation between horizontal and vertical alignment and consider them in combination. It is fundamental to know that there is a strong relation between these two geometric elements – more important than horizontal or vertical alignment individually is how one combines both in a certain road stretch. III But the combination of design elements must meet at least the minimum requirements of either the horizontal or vertical design element.

In any type of road the engineer should bear those facts in mind, although economical motives often speak against them.

With a certain degree of circumspection, when choosing the geometrical elements of both alignments and their relative position, an engineer can reach a good result regarding the optical understanding. This way one also can prevent surprises for road users due to brusque changes and unexpected road characteristics.

The simultaneous existence of more than one of the following elements is likely to produce the double or triple of accidents than in a stretch without those characteristics:

- Gradients
- Intersections
- Curves
– Bridges

A combination of geometrical elements generates a higher accident than each element individually.

Practical design rules amongst others are:

– Limit changes in gradients to a minimum, above all when the horizontal alignment is rather curvaceous

– Vertical curves should coincide in their position with the arcs of horizontal curves and have as similar length as possible, which is also advantageous for the removal of superficial water

– Clear up small angles between straight alignments or successive gradients via curves of big radius

– Prevent the construction of relatively short gradients or straight alignments and substitute them by lengthening of the preceding or following curve

– Focus special attention on the transitions of superelevations, as their shape can be important in the perception of direction changes, especially in convex curves

– At intersections where sight distance needs to be accommodated, both horizontal and vertical curves should be as flat as practical

– Alignments should be consistent with the topography

– Alignments should follow natural contours of the land

To stick to all these rules will not always be possible, but at least one should avoid:

– That vertical curves are positioned over two different horizontal elements

– That the positions of vertical and horizontal curves with extremely different lengths coincide

– Excessive curvature to achieve flat grades

– Excessive grades to achieve flat curvature

– That horizontal curvature is being introduced at or near the top of a pronounced crest vertical curve (Drivers may not perceive the change in the horizontal alignment especially at night)
That horizontal curvature is being introduced near the bottom of a pronounced sag vertical curve (Horizontal curves may appear distorted to the driver; speeds, above all of trucks, are highest at the bottom of a sag vertical curve)

2.1.5. Sight distances

Generally can be said that the longer the sight distances the safer is the road and consequently lesser accidents will happen. When speaking about sight distances one has to distinguish between stopping sight distance, intersection sight distance and passing sight distance.

Any driver should always be able to see the length of the roadway ahead that he/she will drive on. Evidently this is important to drive and steer, to brake and to control the vehicle at any time. This sight distance should always be longer than the distance required to stop the vehicle travelling at or near the design speed, also known as stopping sight distance.

Stopping sight distance is the sum of two distances: the distance traversed by the vehicle from the instant the driver sights an object necessitating a stop to the instant the brakes are applied and the distance required to stop the vehicle from the instant brake application begins.\textsuperscript{xiv}

There are studies that show that by increasing sight distance in general accident frequency will be reduced, especially night accident frequency. They also show that sight distances inferior to 200 m are frequent in horizontal curves with elevated accident rate.

Other investigations demonstrate that elevating sight distance in horizontal curves is highly profitable regarding safety. Low-cost measures as the elimination of roadside vegetation and other minor obstacles should be efficient at the majority of roads.

The passing of slower moving vehicles at rural two-lane roads has to be accomplished by utilising lanes regularly used by the opposite traffic. For that reason the driver of the passing vehicle should be able to see enough road ahead. This road stretch has to be clear of traffic in order to be able to re-entry into the lane before meeting an opposing vehicle.

It is possible that in mountainous terrain with changes in gradient and horizontal curves without enough visibility, separated by straight stretches $\geq 1000$ m, and an elevated AADT ($\geq 3000$ veh./ day) the number of accidents increases due to the
violation of the “no passing rule” at the end of the straight stretch and the consequent invasion of the opposite lane where not allowed.

A very-low-cost measure to avoid this type of accidents is to move the continuous centre line marking (overtaking prohibited) and the vertical prohibition signs (no overtaking) some 50m – 100m backwards. (depending on the measured speed)

By this method will be reached that vehicles that violate the “no passing rule “ in the first metres are still within the limits of the minimum passing distance. But in any case it is important to maintain similar passing opportunities.XV

2.2. Other Elements

2.2.1. Speed

Excessive speed is one of the most frequent reasons for accidents. When inappropriate speed is involved the severity of an accident is likely to be higher. The major influence of speed in accidents is in the energy it brings to collisions. The higher the medium speed the higher is the probability of accidents and of being seriously injured or even killed in an accident.

When the maximum gradient will rise at height differences over 10 meter, there will be a higher influence on the speed of trucks. The decline in speed of more than 20 – 30 km/h as a result of a gradient is from a point of view of traffic safety not acceptable. Possible measures for this problem might be:

- The reducing of the gradient without additional lanes;
- Additional lanes on the left side for passing (fast lanes)
- Additional lanes on the right sight (slow lanes)

International studies learn that passing lanes are more effective than additional lanes for slower traffic, because:

- The right (slow) lanes will be only used by a part of the trucks
- The exchange of lanes by trucks will lead to unsafe situations, because of the unexpected join of traffic.

Numerous investigations prove that there exists a strong relation between changes in medium speed and the number of accidents. About the effect of speed increase or
reduction one can conclude from these studies, that from an increase of 1 km/h of the medium speed the accident frequency grows up 3% and congruously from a reduction of 1 km/h the corresponding decrease.

Results of several studies show that with a reduction of medium speed of 5 km/h one could reach a 25% reduction of seriously injured or killed persons in traffic accidents.

Another point is the relation between speed and fatality of accidents. Obviously the higher the speed the higher is the probability of an accident to be serious or mortal. The passengers of a vehicle involved in an accident whose impact speed was about 80 km/h are 20 times more likely to be killed then if the impact speed was 32 km/h.

This relation is particularly critical for pedestrians. A vehicle hitting a pedestrian at as low a speed as 15 km/h can be fatal yet drivers with proper restraints in a properly designed vehicle can survive high-speed collisions with only minor injury. 5% of pedestrians involved in accidents are killed if the vehicle speed was 32 km/h, if the speed was 48 km/h 45% die and if the vehicle speed was 64 km/h 85% of the pedestrian die.\textsuperscript{xvi}

Research indicates that most people do not use posted speed limits to set their driving speed but rather they feel the road, conditions, traffic, and their vehicle.

To reach a speed reduction where desired a combination of the subsequent measures is most effective.

- Cross-lane rumble strips and other changes in the road surface
- Roundabouts
- Chicanes
- Speed humps, bumps
- Road Narrowing
- Ratio: lane width – height of vertical roadside elements
- Automatic speed control and police enforcement on speed control

2.2.2. Roadside and roadside environment safety elements

Shoulder rumble strips are crosswise grooved or raised patterns in, or on the road shoulder that can be rolled into the hot asphalt or milled in afterwards. The texture of SRS is different from the shoulder surface. When vehicles pass over SRS a sudden
and loud rumbling sound is produced and the vehicle starts to vibrate. An inattentive, drowsy or sleeping driver will be alerted and possibly return to the roadside.\textsuperscript{XVII}

Raised Pavement Markers can be used in conjunction with, or sometimes used instead of painted line markings.

The effect of all kinds of marking, however, can be supported by using RPM additionally. For example they can be used for the better identification of:

- Blind curves
- The course of a road in generally, if the road is hard to perceive
- Areas blocked for traffic
- Pedestrian crossings

Direction arrows in curves are used to indicate a dangerous curve. European countries use them generally in the same way, but the legal conditions for their installation differ.

In Germany the Administrative Regulation for the Road Traffic Regulations (Highway Code, Straßenverkehrsordnung, STVO) explains in which cases drivers have to be warned with direction arrows:

- In case that a driver when approaching a curve is not able to see the further course of the curve and therefore (or for other reasons) gets a wrong impression of the speed to drive in that curve.

In Spain direction arrows have the same function. They:

- indicate the dangerousness of a curve in relation to the speed reduction
- make the judgement of a curves course easier for a driver
- increase safety

In other European countries the scope of application is very similar. For example in Great Britain and Malta they are designated as warning signs that indicate a “Sharp deviation of route to left/ right” and they are likewise used to pull the drivers attention towards the existence of a hazardous curve.

Crash barriers should only be installed if their existence reduce the impact of potential accidents, as the fundamental purpose of crash barriers is to prevent vehicles from abandon the road in an uncontrolled way and hit an object which brings
it to a violent halt or fall down a side slope. In other words: The probable consequences of the accident should be considered as more serious than those provoked by the proper collision with the crash barrier.

Two typologies of safety barriers exist:

− iron (double and triple wave)
− in concrete (New Jersey)

Both the above-described barriers don't result safety-effective for motorcyclists.

The following measures could increase the motorcycle safety:

− installation of metallic barriers with protected vertical supports, covered, for instance, with a cylinder of polymeric material (Image 1);
− guard-rail with a horizontal band that prevents from passing through the wave-shaped iron bands or from staying entangled between the vertical supports, or still from to be cut by the metallic edges (Image 2);
− installation of a uniform barrier, without edges, deformable and constituted by two different elements of energy absorption: stronger at the top, where it is expected a car or truck bump and a soft in the bottom, where there is the actual risk of motorcyclist impact. (Image 3).

It is anyway to be underlined that the best solution for motorcycle safety is the presence of an “escape space”, possibly grassy and level. On the grass, in fact, the body and the motorbike slip slowly dispersing the energy of the fall and in a little traumatic way.
Image 1. Covered Posts

Image 2. Guard-rail with horizontal band
A driver who lost control over his vehicle and left the road tries to get the vehicle back on the road. If the roadside is “forgiving” in the multitude of cases this manoeuvre should be possible. If there were obstacles (trees, very steep embankments…) situated it would lead almost inevitable to an accident.

For that reason obstacles should be situated as separated from the roadside as possible. Uncovered roadside gutters involve a serious risk, even at the slightest inattention. Walls of subsurface drainage structures should be situated adequately.

Studies show that the larger is the distance between roadside and obstacles the less accidents happen and the less severe are the remaining accidents.

Recommendations for obstacle free zones in the Netherlands are:

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<thead>
<tr>
<th>Bandwidth</th>
<th>Obstacle free zone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100 km/hour</td>
</tr>
<tr>
<td>normally</td>
<td>8,00 meter</td>
</tr>
<tr>
<td>minimum</td>
<td>6,00 meter</td>
</tr>
</tbody>
</table>

Table 2. Recommended widths for obstacle free zones according to Handbook Road Safety

![Uniform barrier without edges](image.jpg)
In special occasions it may be advisable to build an even wider obstacle free zone:

- To comply with the necessary stopping sight distance
- On road stretches where higher speeds are allowed

To reach a high level of road safety it is advisable to build embankments as flat as possible. One should never build a slope steeper than 3:1, because drivers are not able to control vehicles on those slopes - the vehicle would overturn.

A clear and efficient signing system is a key element for real road safety improvement; it is characterized by forms and colours: those characteristics must be maintained during the day and at night.

The more a sign is placed near the centre of the driver's visual field, the better it is recognized in advance.

The signs placed over the carriageway must be centred on the roadway axis (or on the lane axis, if related to only one lane) and should have an adequate inclination with respect to the plane perpendicular to the road axis should be adopted, usually around 3°-4°, as shown in Figure 1.

![Figure 1. Inclination of signs placed over the carriageway](image-url)
In the daytime the visibility of the system of signs is guaranteed by the contrast between the white colour of the road markings and the dark colour of the pavement, while at night the perception of the markings for the human eye decreases.

The solution for maintaining the visibility is the application of glass micro spheres, to get the retro-reflection of the car lights to the driver, allowing him to easily distinguish the signals.

LEDs traffic signals represent a valid alternative to the incandescence lamps.

The principal advantages of the LEDs in comparison to the ordinary lamps are:

- lower consumption (up to 80% in less);
- greater duration (over 10 times);
- strong reduction of the maintenance;
- greater safety (better visibility under critical conditions no false signal due to the sunlight) and elevated reliability.
2.2.3. Emergency escape ramps

Roads with long descending grades and heavy vehicles driving on them often represent potentially dangerous conditions for the truck drivers themselves, for other drivers, and for occupants of roadside property.

Frequent causes of those incidents are:

- Failure of the brakes
- Driving error (inadequate speed)
- Driver inexperienced with the vehicle or in mountainous terrain
- Inadequate traffic signs on crests

Under the former mentioned conditions the construction of an emergency escape ramp at an appropriate location is desirable for the purpose of slowing and stopping an out-of-control vehicle away from the main traffic stream.

Emergency escape ramps turned out to decrease the accident frequency and severity. When situated on appropriate sites they can reduce costs of heavy vehicle runaway accidents to a great extent.

2.3. Driveways, intersections and junctions

Accesses are one of the most frequent causes of risk. When traffic coming from another road is introduced in a road a conflicting traffic flow is created. That includes traffic coming from other road infrastructures, intersections, local, public and private ways as well as left turns. Access control means to space, reduce or eliminate the variety of events to which the driver has to respond. It is one of the most important factors in accident reduction.

2.3.1. Driveways and access points

The separation of points where decisions have to be made, the elimination of unforeseeable events and the control of access from lateral properties are reasons why highways have a higher level of safety than other roads.

By access control roads can be made safer. For example by building or using a lateral road or street to which adjacent properties have access one can reduce the number of accesses to a road. Further away this lateral road has access to the main
road. This modus operandi has considerable results on roads with elevated traffic density.

Often it is not possible or practical to eliminate the accesses, although reducing the conflict level in access points may moderate the negative effects of accesses. For example by:

- Reducing the number of accesses
- Eliminating left turns
- Providing lateral (parallel) roads/streets
- Providing lanes for turnarounds
- Providing acceleration/deceleration lanes

As dangerous as lateral accesses are left turns so the engineer should try to reduce the number of left turn possibilities. This does not mean that one should eliminate all left turns completely but reduce the number and make the remaining safer.

An excellent solution is the construction of grad separated left turn possibilities instead of crossing the oncoming traffic.

### 2.3.2. Comparison of intersection types

The table below points out the main points for intersections between secondary roads and other road categories in the Netherlands.

<table>
<thead>
<tr>
<th>Primary road: slip roads</th>
<th>Secondary road</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Roundabout, or</td>
<td>- all way stop/yield controlled possibly with traffic light and/or speed reduction measures</td>
</tr>
<tr>
<td>Secondary road:</td>
<td>- Roundabout, or</td>
</tr>
<tr>
<td>- all way stop/yield controlled possibly with traffic light and/or speed reduction measures</td>
<td></td>
</tr>
<tr>
<td>Local road</td>
<td>- Roundabout, or</td>
</tr>
</tbody>
</table>
### Roundabout

A roundabout is the safest form of intersection (all legs on the same level).

Roundabouts are normally used in the following situations:

- Intersections between two secondary roads;
- On accentuated locations like city-borders and change of road categories.

#### Traffic safety on Roundabouts

A roundabout (single lane) is the safest form of intersection, because:

- The real speed of the drivers is very slow. The lower the speed, the lower the chance on accidents or hospital injured/deaths.
- On a roundabout there is a reduction of possible conflict situations. Each connecting road is one well-organized situation.

A single lane roundabout is safer than a roundabout with two lanes. This goes especially for just material damage on the collided objects and less for the injured (hospital/deaths) as a result of an accident.

From the point of view of traffic safety single lane roundabouts are preferred to two lane roundabouts.
Stop/yield controlled intersections

The design of stop/yield-controlled intersections must support the right of way. Because of this reason and reasons of traffic safety the following design elements are necessary:

− A left turn on the main road
− A lane separation on the side road
− A maximum of one single lane for through traffic per direction
− A maximum of one single lane on the side road.

Traffic safety on Stop/yield controlled intersections

The amount of traffic explains more than half of the variation in accident ratings on stop/yield-controlled intersections. The influence of the amount of traffic on side roads is more than the amount of traffic on the main road.

When stop/yield controlled intersections with three legs are compared with stop/yield controlled intersections with four legs it seems that three legs intersections are more safe than four legs intersections.

The lane separation on the side roads shouldn’t be too high because of the chance on collisions.

Signalised intersections

Stop/yield controlled intersections are normally provided with traffic lights because of problems with the capacity or flow of traffic. A traffic light is normally not used only because of traffic safety.

Traffic safety on signalised intersections

A stop/yield controlled signalised intersection is used on a secondary road when a roundabout is not possible because of a lack of space. The placement of traffic lights just because of the improvement of traffic safety must be considered carefully. This goes especially for intersections with a small amount of traffic (because of red light ignorance). On the other hand, an intersection with a large amount of traffic signalised is safer than not signalised.

A study conducted in 1994 by Schnüll et al.\textsuperscript{XXII} deals with the safety comparison of the basic junction forms crossroad and staggered junction on roads outside build-up areas. The aim of their research work was to develop recommendations for the areas
of use of the basic junction forms crossroads and staggered junction. Some of the results of the accident investigation are summarised in the subsequent table.

<table>
<thead>
<tr>
<th></th>
<th>Crossroads equipped w. signals without left-turn filter and turned off at night</th>
<th>Crossroads equipped w. signals +left-turn filter+ not turned off at night</th>
<th>Partial Grade Separated</th>
<th>Staggered Junction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Accident Rate</td>
<td>0.93</td>
<td>1.31</td>
<td>0.86</td>
<td>0.94</td>
</tr>
<tr>
<td>[acc./10^6veh.]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accident Cost Rate</td>
<td>80.40</td>
<td>36.80</td>
<td>38.60</td>
<td>37.20</td>
</tr>
<tr>
<td>[DEM/10^4veh.]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accident of Medium</td>
<td>86.000</td>
<td>41.000 - 44.000</td>
<td>41.000 - 44.000</td>
<td>41.000 - 44.000</td>
</tr>
<tr>
<td>Seriousness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[DEM/acc.]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Characteristic accident values for different intersection types (Schnüll et al. 1994\textsuperscript{XXII})

The investigation for determination of the causes of accident imply that, due to the system by which they operate, crossroads have a significantly accident higher risk than staggered junctions and other junction forms.

For this reason crossroads should be used only on roads with low traffic volume and low traffic speeds and should be avoided where possible. Crossroads with rather high traffic volume and high speeds should be equipped with traffic lights or other junction types such as roundabouts or staggered junctions should be used.

Compared to crossroads staggered junction have also a higher performance (sum of all vehicles driving into the junction) supposing an average turning-off fraction. Crossroads: 12.000 veh/ day and staggered junctions 15.000 veh/ day.

Schnüll et al.\textsuperscript{XXII} investigated a large number of assessment criteria such as characteristic accident values, performance, environmental compatibility and Cost-effectiveness and came to the result that staggered junctions in contrast with crossroad have in principle only advantages. But they also mention that a comparative assessment with respect to the basic junction forms partial grade separated, roundabout and crossroad equipped with traffic lights should be performed.
Another study by Eckstein et al.\textsuperscript{XXIII} conducted in 2002 also compared the safety of junction types. They came between others to the following findings:

- Accident cost rates of junctions depend on basic type (junction design) and traffic control
- Accident cost rates of junctions are independent of traffic volume
- Junctions influence safety of neighbouring road sections
- Small roundabouts have the lowest accident cost rates and therefore the best safety level
- Small roundabouts are followed by half cloverleaf junctions (the crossing road is grade separated)
- T-intersections are safer than crossroads but since two T-intersections are needed to dissolve one crossroad it can not generally be said that the sum of two T-intersections is safer than one crossroad (in contrast to Schnüll et al.\textsuperscript{XXII})
- Traffic lights increase the safety level only when used with more than two phases
- STOP/YIELD-controlled T-intersections and crossroads have the lowest safety level. Traffic lights with two phases do not increase the safety level.

The next chapter elaborates on roundabouts, since numerous studies describe them as the safest at-grade intersection type.

2.3.3. Roundabouts

Roundabouts are relatively easy to understand because of their simplicity and uniformity in functioning. Apart from that they provide a comfortable possibility to turn to the opposite direction (U-turn) and to find the right exit (by driving another round). At roundabouts exists the possibility of the subsequent incorporation of an additional leg, always if there is enough clearance.\textsuperscript{XXIV}

In most western European countries as Great Britain, France, Spain, Germany, Switzerland, Norway, Portugal, The Netherlands etc. roundabouts have established themselves and in some cases they are already quiet widespread.

According to Ourston et al.\textsuperscript{XXV} the most important operational element of a modern roundabout is the YIELD-control at the entry, which allows the circulating traffic to
keep always moving. This operational procedure works also well with heavy traffic. And since no weaving distance is necessary the roundabouts keep compact.

But there are more features that characterise this kind of intersection and make it at the same time the safest at-grade intersection type. Those characteristics of modern roundabouts are:

- The path of entering traffic aims at the centre of the central island and is deflected slowly around it, which leads to speed reduction, increased awareness and thus to accident reduction.

Figure 2. Deflection of the vehicle path, (Source XXV)

- The roadway of the entering traffic are often flared to provide additional lanes (only within the roundabout) and thus high capacity in a compact space.

Figure 3. Entry Flare, (Source XXV)

- To control entry speed and deter left turns all approaches are provided with splitter islands.

- Low number of conflict points at a roundabout compared with other junction types

- Separation of conflict points

- One-way operation of circulating carriageway
− Availability of enough sight distance at the approaches.
− Crosswalks are not allowed across the circulatory roadway.
− Parking inside the roundabout is not allowed.

When converting different junction types into roundabouts several countries conducted “before-after-studies” to show the effect of this measure in accident reduction. In general quite large reductions were found, with exception of accidents involving two-wheelers, where the reductions were rather small.\textsuperscript{XXVI}

The following table\textsuperscript{XXVII} illustrates the results of several international studies regarding accident reduction.

<table>
<thead>
<tr>
<th>Country</th>
<th>Mean Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Crashes</td>
</tr>
<tr>
<td>Australia</td>
<td>41 - 61%</td>
</tr>
<tr>
<td>France</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>36%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>47%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>37%</td>
</tr>
</tbody>
</table>

Table 5. Mean crash reductions in various countries\textsuperscript{XXVII}

In addition roundabouts, if designed properly, afford safety benefits for pedestrians and bicyclists. The minimising of the potential relative speeds between two vehicles will minimise the multiple vehicle crash rate and at the same time optimise capacity. That can be reached by two ways:

− Reduction of the absolute speed of both vehicles
− Reduction of the angle between the vehicle paths

Given a medium bicycle speed of 20 to 25 km/h vehicle speeds should be adapted and thus the relative speed between them would be reduced. Lower absolute speeds will also assist pedestrian safety.

Other design recommendations for rural roundabouts are:

− Reduce shoulder widths and introduce curbs (prevent “corner cutting”)
− Reduce approach speeds by using longer splitter islands on the approaches
− Use landscaping on the extended splitter island and roadside to create a “tunnel” effect
Use of successive reverse curves with successively smaller radii on approaches

![Diagram of roundabout with various radii](image)

Figure 4. Use of successive curves on high speed approaches

An important characteristic of roundabouts regarding accident frequency is the number of legs, as a British study clearly illustrates. Table 6 shows, as was to be expected, that the accident frequency increases with the number of arms.

<table>
<thead>
<tr>
<th>Nº of legs</th>
<th>Nº of sites</th>
<th>Accident frequency</th>
<th>Severity (% of fatal and serious accidents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>326</td>
<td>0.79</td>
<td>9.3</td>
</tr>
<tr>
<td>4</td>
<td>649</td>
<td>1.79</td>
<td>7.1</td>
</tr>
<tr>
<td>5</td>
<td>157</td>
<td>3.66</td>
<td>7.1</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>5.95</td>
<td>5.2</td>
</tr>
<tr>
<td>All</td>
<td>1162</td>
<td>1.87</td>
<td>7.2</td>
</tr>
</tbody>
</table>

Table 6. Accident frequency at U.K. roundabouts by number of arms 1999 - 2003
Table 7 shows accident frequencies from several countries as well as medium accident frequencies for Europe, overseas and for all sites. The medium accident frequencies for all sites and for Europe are very similar, due to the fact that the biggest samples come from European countries.

2.3.4. Grade-separated intersections

The capacity of an at-grade crossing should be controlled by the characteristics of the main road. At-grade intersections provide many opportunities for vehicle conflicts and therefore they are likely to have an elevated number of accidents.
One out of a number of possible solutions to the problem is the conversion into a grade-separated intersection. From the safety point of view the provision of grade-separated intersections is very advantageous but the initial construction costs when compared to at-grade intersections are rather large. Therefore the planning engineer should carefully weigh up and use the following conditions to justify his decision. A grade-separated intersection should be provided:

- If a free movement of the through traffic is desired
- If an existing traffic bottleneck is to be eliminated
- If an existing accident black spot is to be eliminated
- If the economic losses due to traffic delays are considerably high (on a long term consideration the initial construction costs can be inferior to the costs for fuel, tyres, oil, repairs and accidents, as well as the time costs of the road-users)
- If topographic difficulties make the construction of an at-grade intersection more expensive than a grade-separated intersection

XXVIII
3. Development of SEROES

Most road safety measures are known to have a positive effect on accident reduction. Due to interactions with the surroundings, other road users or other elements of the road, some measures don’t have any effect on safety or their effect is even negative. To find out which measures are more effective in accident reduction or accident severity reduction investigators in Europe and all over the world have conducted statistical analyses on different measures. This knowledge is summarised in the “Handbook of Road Safety Measures” by Rune Elvik and Truls Vaa, which gives a systematic overview of the current knowledge concerning road safety measures and their effect.

After closer examination of the available information is has been decided that the computer program that will be used for SEROES will not be literally an Expert System containing a knowledge base and a set of algorithms or rules able to infer new facts from knowledge and from incoming data. The data fit much better into a classic computer program, containing a data base with several sets of data (measures, causes, incident sites……) which have been connected between each other and thus the software is able to generate a result for a given problem.

The most important issue of the SEROES is that the application is meant to grow in the future. That means that new knowledge should be added and the existing measures will be modified where necessary, in terms of effects or costs. SEROES is meant to be a road safety forum where practitioner interchange information and contribute this way in the improvement of the application.
3.1. References

SEROES was developed based on Elviks and Vaas work. In the Handbook of Road Safety Measures all measure types are analysed identically to get an overview and make it easier to compare them. Special attention is turned on the measure’s effect on accidents, the effect on mobility, the effect on the environment and the costs of the measures. Where possible a cost-benefit analysis is carried out. 124 specific traffic safety measures are described in a structured way. Dependent on the acceptance of a measure and the extent it has been researched, to some measures is paid more attention that to others. The handbook deals with the following categories of measure:

- Road Design and Road Furniture
- Road Maintenance
- Traffic Control
- Vehicle Design and Protective Devices
- Vehicle and Garage Inspection
- Driver Training and Regulation of Professional Drivers
- Public Education and Information
- Police Enforcement and Sanctions

Since a number of measures aren’t appropriate for this purpose, SEROES picks up 17 measures from “Road Design and Road Furniture”, 9 measures from “Road Maintenance”, 17 from “Traffic Control” 2 from “Public Education and Information” and 1 measure from “Police Enforcement and Sanctions”.

It is further based on the D9.1 report of the RIPCORD-ISEREST project, which deals primary with studies that relate road safety relevant elements in a quantitative way with accident occurrence but mentions also other research work which describes this relation in a rather qualitative manner. The a summary of D9.1 is represented in chapter 2.

The software is directed to road authorities and administrators responsible for (secondary) roads infrastructure and is thought to serve as a base of decision making.
The system could be especially useful for small and medium road administrations of European countries, with limited financial possibilities and a lack of detailed accident data.

The application can be found under www.seroes.com and www.seroes.eu.

More references to existing sources of information are included under SEROES→Options→Interesting Links

Interesting Links:

CARE
European Road Accident Database
ec.europa.eu/transport/roadsafety/road_s...

ROAD SAFETY RESEARCH
crafts.geocities.com/hauer@rogers.com/index....

STRATEGIC HIGHWAY SAFETY PLAN
safety.transportation.org/

TRB
The Transportation Research Board
www.trb.org/default.asp

AUSTROADS

PIARC Road Safety Manual
or under SEROES → Options → Related Products

Related products:

- **CD-ROM: FGSV**
  Instruction leaflets for the analysis of road traffic accidents,
  Author: Forschungsgesellschaft für Straßen- und Verkehrswesen
  [www.verkehrstechnisches-institut.de/cont ...](http://www.verkehrstechnisches-institut.de/cont ...)

- **THE HANDBOOK OF ROAD SAFETY MEASURES**

- **IHSDM**
  Interactive Highway Safety Design Model

3.2. Interactions between SEROES and Road Authorities during a road infrastructure safety intervention process

Road authorities can use SEROES for infrastructure safety interventions using the following procedure:

1) Accident analysis
   a) Accident data analysis of the single infrastructure or of the Road network
   b) Localization of Black spots or stretches with high accident density and choice of action priority
   c) Determination of the accident types to deal with at each critical point
   d) Determination of the accident causes

2) Determination of the possible safety measures
   a) Description of the measure
   b) Effects on accidents
   c) Intervention cost

3) Evaluation and choice of proposed safety measures
   a) Cost- Benefit or multi-criterion analyses of proposed measures;
   b) Choice of safety measure to be applied
   c) Operational planning to implement adopted measures

4) Implementation of safety measure
   a) Analysis of the real implementation cost.

5) Accomplished safety measures monitoring
   a) Analysis in terms of rate variation on accidents.

Infrastructure or Road network Authorities could be assisted by SEROES during the following steps:

- Within the "Accident Analysis" it can help determine possible accident causes only after a thorough analysis of the infrastructure or road network initially.
Within the “Determinaton of the possible safety measures” Road authorities can choose among different safety measures and, above all, know the expected intervention costs and their effect on safety. (the given effects on accidents are the results of a number of studies that have been combined into an overall estimate of the average effect of a measure. Therefore the user should not interpret the given value as something really reliable but as a value that can be used to compare different measures that have for example similar costs)

Road Authorities will, in turn, contribute to the continuous learning of SEROES:

- Within the “Determinaton of the possible safety measures” Road Authorities can suggest new measures with relevant expected implementation costs and effects.

- Within the “Implementation of safety Measures” Road Authorities shall indicate the real implementation costs of interventions.

- At the end of the “Monitoring of the effected safety measures” Road Authorities shall be able to validate or not the effects on the safety occasioned by the safety measure.

It is our goal to convert SEROES into a road safety forum, where the user contribute new measures, discuss their effect and make remarks to local costs for measures in different countries.
The following shows interactions between SEROES and Road Authorities.

### ROAD AUTHORITIES

#### Incidetality analysis
- Incidetality data analysis of the single infrastructure or of the Road network
- Localization of Black spot or stretch with high accident density and choice of action priority
- Determination of the accident types to tackle at each critical point
- Determination of the accident causes

#### Determination of the possible safety measures
- Description of the measure
- Effects on incidetality
- Intervention cost

#### Evaluation and choice of proposed safety measures
- Benefit-cost or multicriteria analyses
- Choice of safety measure to be adopted
- Operational planning to implement adopted measures

#### Implementation of safety measure
- Analysis of the real implementation cost

#### Accomplished safety measures monitoring
- Analysis in terms of rate variation on incidetality

Image 6. Interactions Road Authorities and SEROES
3.3. Terms used in the SEROES application

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incident Site</td>
<td>A place where an accident event took place</td>
</tr>
<tr>
<td>Accident concentration spot</td>
<td>Location with an abnormal high number of accidents</td>
</tr>
<tr>
<td>Accident concentration spot at or near intersection</td>
<td>Location with an abnormal high number of accidents at or in the surroundings of intersections</td>
</tr>
<tr>
<td>Stretch with high accident density</td>
<td>Road stretch with an abnormal high number of accidents</td>
</tr>
<tr>
<td>Crossing accident or angle collision</td>
<td>Accident between at least 2 motor vehicles at an intersection, travelling on different (crossing) roads.</td>
</tr>
<tr>
<td>Meeting accident or Head-on collision</td>
<td>Accident where the front end of one vehicle collides with the front end of another while the two vehicles are travelling in opposite directions.</td>
</tr>
<tr>
<td>Rear end collision</td>
<td>Accident where the front end of one vehicle collides with the rear end of another vehicle while the two vehicles are travelling the same direction.</td>
</tr>
<tr>
<td>Passing or overtaking collision</td>
<td>Accident where one vehicle collides with another vehicle during an overtaking manoeuvre while the two vehicles are travelling the same direction.</td>
</tr>
<tr>
<td>Run of the road or overturned accident</td>
<td>Single vehicle accident where the vehicle runs of the road or overturned (or both).</td>
</tr>
<tr>
<td>Turning collision</td>
<td>Accident where one vehicle collides with another vehicle during an turning manoeuvre, travelling on different roads at an intersection.</td>
</tr>
<tr>
<td>Cause</td>
<td>Anything that produces something (an effect); in accident research the term is controversial, if used at all it usually denotes risk factors that are statistically denoted with accidents.¹</td>
</tr>
<tr>
<td>Costs</td>
<td>Costs here is the price to pay for a measure.</td>
</tr>
<tr>
<td>Objective</td>
<td>Target of a certain measure.</td>
</tr>
</tbody>
</table>
4. Implementation of the Best Practice Safety Information Expert System SEROES

4.1. How to start with SEROES

SEROES can be used without much experience in road safety and the collecting and processing of data necessary for a deeper analysis. The first steps are described below.

- To begin the user has to visit one of the above mentioned web-pages; afterwards the first step is to open an account. To do that the Request a user option within the Options menu has to be called.

Once the registration form has been filled in and the confirmation about the activation of the account, the user name and the password has been received the new user can sign in.
- Information about the product, the partners, the project etc. can be found in the Options menu.

- To actually start SEROES the Expert System Access option within the Seroes menu has to be called.

Image 8. Menu: Seroes

- If any problems arise during the registration process the Help option can be used (PDF) or an email to the administrator can be written.
4.2. Structure and Functioning

The application is structured into various menus for users and an additional menu for administrators. The additional administrator tool will be described further down. The most important menus are Options and Seroes.

Options is an informational menu. Under Options the user can find any kind of information regarding the partners that participated in the development, the RIPCORD-ISEREST project partners, the application, related products, the registration form etc.

Under Seroes the actually access to the application can be found. The application SEROES can be subdivided into two main blocks: The Input and the Output.

Input: The user has to describe the road safety problem he would like to solve. This description has to be carried out within 3 steps. In every step it has to been chosen between various options.

Depending on the characteristic feature chosen in the previous step, the options in the next step are limited so that only logical sequences are eligible.

The sequence of 3 steps goes:

- Incident Site:
- Accident Type:
- Cause:

![Image 9. Example for Input](image)

Output: Once the Input is finished the application offers one or several measures as a solution. For each of the measures the following information will be provided:

- Objective
- Description
- Effect on accidents where:
  - ⪞ sign means accident reduction
  - ⪟ sign means accident increase
- Cost Range (€/Km)
- Get Information

In most cases the user can additionally choose between the effects on different types or severities of the accidents.

All information is stored in a database, which is expandable and can be modified.

4.3. Administrator tool

SEROES has an additional menu for administrators. Within this menu are the subsequent options which allow the administrator(s) to modify the content of the database and to govern users:

- Scene Definition
- Incident Site
- Accident Type
- Cause
- Measures
- Type of accident affected
- Users
- Library of Documents

4.3.1. Scene Definition

The centre-piece of the administrator tool is the scene definition menu item where the administrator can define new proceedings (scenes) by connecting a new set consisting of an incident site, an accident type, a cause and a measure from the database and thus enlarge the system.

Image 11. Scene definition: Incident site selection
Scene Definitions:
Select an Accident Type and press next button to continue

Incident Site:  Accident concentration spot

- Collision with animal
- Collision with bicycle
- Collision with parked vehicle
- Collision with pedestrian
- Crashing accident or angle collision
- Meeting accident or head-on collision
- Other single vehicle accident
- Passing collision
- Rear end collision
- Run off the road, overturned or other single vehicle accident
- Turning collision
Image 13. Scene definition: Cause selection
Image 14.  Scene definition: Measure selection

<table>
<thead>
<tr>
<th>Measure</th>
<th>Objective</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>At grade crossing points cyclists at intersections</td>
<td>The measure separates cyclists optically for motorised traffic, helps them to cross the road and gives increased mobility and a feeling of security.</td>
<td>Canalised crossing facilities for cyclists at intersections. (also possible mid-block or equipped with traffic lights)</td>
</tr>
<tr>
<td>Black spot treatment</td>
<td>Accident black spot treatment seeks to modify the road or traffic control in a way that can reduce the expected number of accidents at places where it is particularly high.</td>
<td>Black spot treatment</td>
</tr>
<tr>
<td>Black spot treatment</td>
<td>Accident black spot treatment seeks to modify the road or traffic control in a way that can reduce the expected number of accidents at places where it is particularly high.</td>
<td>Black section treatment</td>
</tr>
<tr>
<td>Black spot treatment</td>
<td>Accident black spot treatment seeks to modify the road or traffic control in a way that can reduce the expected number of accidents at places where it is particularly high.</td>
<td>Accident black spots and places nearby</td>
</tr>
<tr>
<td>Winter Maintenance of roads</td>
<td>Keeping roads free of ice and snow during the winter period is intended to increase friction and visual conditions and thus reduce the number of accidents.</td>
<td>Increasing length of road protected by snow from 0% to 50%</td>
</tr>
<tr>
<td>Winter Maintenance of roads</td>
<td>Keeping roads free of ice and snow during the winter period is intended to increase friction and visual conditions and thus reduce the number of accidents.</td>
<td>Increasing standard of maintenance by one friction class throughout the whole winter season</td>
</tr>
<tr>
<td>Winter Maintenance of roads</td>
<td>Keeping roads free of ice and snow during the winter period is intended to increase friction and visual conditions and thus reduce winter season the number of accidents.</td>
<td>Introduction of salting throughout the whole winter season</td>
</tr>
<tr>
<td>Winter Maintenance of roads</td>
<td>Keeping roads free of ice and snow during the winter period is intended to increase friction and visual conditions and thus reduce winter season the number of accidents.</td>
<td>Cessation of salting throughout the whole winter season</td>
</tr>
<tr>
<td>Winter Maintenance of roads</td>
<td>Keeping roads free of ice and snow during the winter period is intended to increase maintenance preparedness (more friction and visual conditions and thus reduce winter season the number of accidents.</td>
<td></td>
</tr>
</tbody>
</table>
4.3.2. Incident Site

At present there are three different incident sites to choose from. In case it appears appropriate to add other incident sites, this can be done by using this part of the administrator tool. Subsequently the new incident site can be connected within the scene definition menu with the other components.

4.3.3. Accident Type

Currently there are several different accident types defined. Within the accident type menu item new accident types can be added and accident types that are not anymore in use can be deleted. Within the scene definition menu the new accident types can be connected with the other components.

4.3.4. Cause

The same way as before new causes of accidents can be added. A number of accident causes is already defined. By using the cause menu item the administrator(s) can easily add new causes and connect them subsequently to other the components.

4.3.5. Measures

Each measure is composed of a Name, an Objective of the measure, a Description of the measure, a Type of accident affected, a Best Estimate for the accident reduction potential, a Confidence interval for this reduction potential, a statement if the best estimate is statistically significant or not and a Cost Range.

To define a new measure the first step is to fill in the text in the name, objective and description fields.

In the second step a type of accident affected has to be chosen from a pull-down menu, subsequently the numbers for Best Estimate and Confidence Interval have to be filled in. Afterwards the administrator has to choose Yes or Not from another pull-down menu for the Significance and finally fill in the Cost Range. Additional information regarding the measure can be provided in a separate field.

The second step can be repeated for another type of accident affected by the same measure to differentiate for example between the effects of the measure on injury accidents and property damage only accidents.
4.3.6. Type of accident affected

Using the same procedure as in incident site, accident type, a cause the list of possible types of accidents affected by a measure can be expanded or reduced too. Subsequently the new type of accidents affected can be used within the measures menu item to describe the effect of a measure on this new type of accident affected.

4.3.7. Users

The user menu item provides an easy tool to administer the users. Users can be registered to the system, deleted from the system or their user data can be modified.

4.3.8. Library of documents

With this tool the administrator(s) can upload documents which afterwards are visible to all users.
5. Demonstration of SEROES

5.1. Aim of the demonstration of SEROES (WP 9) and the DST (WP 11)

SEROES → Secondary Roads Expert System

DST → Decision Support Safety Tool

The aim of the demonstration regarding SEROES was triple:

- To introduce the RI-Project in different EC-countries
- To test the relation between SEROES and the DST (transfer measures from SEROES to the DST)
- The validation of SEROES

5.2. Demonstration

SEROES is demonstrated together with the DST (WP 11 en 12) in three countries: Turkey, Poland and the Netherlands. The demonstration of SEROES was integrated in the demonstration programme of the DST in WP12.

The demonstration existed of this programme:

- Introduction of the attendants
- Introduction EC-project RIPCORD-ISEREST
- Aim of this training/demonstration
- Short introduction of the DST (WP 11)
- Preparation of the DST
- Introduction applications within the RI-project (including SEROES)
- Process road safety and the DST (including SEROES)
- How to run the DST
• Different working-sessions with SEROES and the DST

The attendants to these demonstrations had different backgrounds: national, regional and local road managers, researchers and consultants.

5.3. SEROES

SEROES was an important part of the demonstration. First of all, the most important and relevant measures regarding secondary roads from SEROES were transferred to the measure database within the DST (170 measures). Besides this, SEROES was used as an important tool within the road-safety process that is demonstrated and used in the working-sessions. Within this demonstration this road-safety process is used within the working-sessions:

First of all, the attendants used the Accident Prediction Model (WP 2) and the accidents analyses to study on the road safety problem at their road/intersection. The next step is to use SEROES to select appropriate measures regarding the road safety problems. The final step is to implement the appropriate measures into the DST in order to receive information about the total costs and effects of all implemented measures.

More information about the demonstrations can be found in the final deliverable of WP 12.
5.4. Evaluation

Structure of the evaluation

The evaluation of SEROES was executed in two ways:

− An evaluation after the demonstrations in WP 12
− A questionnaire to a number of possible users of SEROES in different EC-countries

After the demonstration the attendants evaluated the process of the structure of work within SEROES, the quality of the information and the relation between SEROES and the DST.

5.5. Questionnaires

The questionnaire was elaborated with the aim of demonstrating the functioning of SEROES. It was sent to a number of users of SEROES, especially for the Turkish region.

The users had to indicate their agreement with each statement on a scale of 1 - 5, as set out below.

1. Totally disagree  … was unacceptable
2. Disagree  … was less than I expected
3. Marginal  … this was average …
4. Agree  … was above average
5. Totally agree  … was excellent

The questionnaire, which is shown in Annex 2, is structured in five sections.

The first section is dedicated to the comprehensibility of the tool. The aim of this segment was to find out if the users had any problems with understanding the application.

In the second section the users had to answers questions about the functioning of the Expert System.

The impression of the users about the output and interpretation of the results was asked in the third section.
An important element of the demonstration of the Expert System was the applicability in real live situations. This topic was queried in the fourth section.

In the last section the users had answer to some questions regarding the overall impression of the application.

Finally the users were requested to make further comments, suggestions or remarks.

5.6. Results of Questionnaires

The results were summarised in the subsequent figure. By and large it can be said that the users impression was positive.

As one can perceive when looking at Figure 5 the average impression regarding the comprehensibility was that the users agreed with the statements of the questionnaire. The same can be said about the functioning.

The respondents impression regarding the output and interpretation of the results and the overall impression was positive too although the opinions here lied between average and above average.

The average impression regarding the usefulness and applicability in real live situations of the Expert System was just ‘marginal’.
Figure 5. Synopsis of the questionnaires results
5.7. Summary of comments and suggestions

- It has been recommended to make a distinction between rural environment and built-up environment or a distinction between urban roads, rural roads and motorways.

- It has also been made the remark that the Expert System gives simplified answers to rather complicated questions. On one hand it was said that an accident in reality has always more than only one explanation and that it is the result of a number of factors as design, environment, weather, other road user, their behaviour, etc. On the other hand there is often more than one possible solution to each problem. It would be advantageous to study the site, the surroundings and the behaviour of the road users. (before proposing any measure)

- It was mentioned that SEROES neither helps the user to identify accident-prone locations nor clarifies the meaning of terms as “accident-prone location”, “high accident rate”, “high accident density”, “high degree of accident severity”, nor gives answers to questions as “What are normal accident outcomes for different locations and conditions?”

- It has been observed that the Expert System does not help the users with basic knowledge of accident statistics (e.g., that accident reporting is often deficient and underreporting frequent, definition of severe and slight injury, difference between fatal accidents and fatalities, injury accidents and injuries).

- Furthermore it has been detected that SEROES does not help the user with the “diagnosis”, i.e. how to study accident patterns and to identify accident contributing factors and deficiencies.

5.7.1. Incident Site

- It was proposed to drop the choice "accident concentration spot at or near intersection" and to leave only accident types where it is already obvious if the accident occurred at an intersection or not
5.7.2. Accident Type

- It was mentioned that the meaning of the term ‘accident type’ might not be clear. Since the concepts of ‘accident type’, ‘collision type’ and ‘conflict type’ may be different from country to country, the used terms should be clearly explained, in order to avoid misunderstandings.

- It seems that in Germany a “collision with pedestrian” is a type of "crossing accident" and therefore it doesn't make sense to have both parallel under accident types. That could be avoided by using the German accident type catalogue together with a choice of road user type.

5.7.3. Cause

- In some cases an incongruence between ‘cause’ and ‘measure’ was observed, e.g. after choosing ‘inadequate speed’ as cause, ‘warning about road works’ was always offered as ‘measure’.

- It was proposed to change the choice “causes” in “deficits”, since not all “causes” are real causes but deficits.

- The term “accident contributing factors” instead of “causes” was also proposed since there is seldom only one cause for an accident.

5.7.4. Measures

- It has been commented that some measures are not sufficiently detailed. For instance, “black spot treatment” seems to be too superficial as a “measure” for certain “causes” of accidents at accident concentration spots.

- The use of illustrations was recommended to elucidate unclear measures.

- It was observed that the Expert System could be enlarged using local experiences in the application of measures. For example the effect of different road surface types after having conducted surface renewal works.
5.7.5. Effect

- It was also mentioned that the Expert System doesn’t deal with prioritizing, i.e. to find the best action plan (or investment programme), according to some defined criteria, and based on estimated effects and costs as well as budget restrictions. The ES does not mention the problem of setting monetary values to accident and casualty reductions, which is needed for cost-benefit analysis.

- The ES does not mention the importance of follow-up and evaluation in order to verify and improve the knowledge of safety effects.

- It was proposed to change the specification of the effect into a categorisation of low, middle and high using appropriate limits.

- The suitability of indicating precise effect values (on percent level) was questioned when the existence of huge variations is a known fact. The use of an interval was proposed. It was mentioned that the effect values could be adjusted for the country in question, e.g., by considering actual road user behaviour and road design.

- It doesn’t seem to be clear, what exactly the effect values indicate.

5.7.6. Cost Range

- It has been noticed that not for all measures has been provided a cost range but sometime precise costs.

- It was proposed to change the specification of the cost range into a categorisation of low, middle and high using appropriate limits.

- The suitability of indicating precise costs or costs ranges was also questioned, because of the existence of huge variations in different regions/countries and of the differences in the actual design of the measure.

- It should be considered to study one low-cost and one higher-cost alternative for each location, and in particular to estimate the marginal benefits and costs for the higher-cost alternative. Often low-cost alternatives yield better total value for money because they permit improvement of more locations within the budget restriction.
6. Practical use of SEROES

The following chapter shows some fictitious cases of SEROES use.

It has to be assumed that Road Authorities have carried out an accident analysis of the Infrastructure or Road Network.

As a result the Road Authorities determined black spots and/or high accident density stretches. For each of these zones they possess data on:

- Accident surveyed
- The type of accident to deal with
- The possible accident cause

In order to determine the possible cause of accidents the Road Authorities can use the list in SEROES.

Afterwards, SEROES suggests a series of safety measures.

To each of these measures objectives have been assigned, average costs of the interventions, and the average values of the effect on accidents, sometimes different according to the accident severity.
6.1. Examples of SEROES use

6.1.1. Example 1

Incident Site: Stretch with high accident density

Accident Type: Meeting accident or head-on collision

Cause: Dangerous situations can easily arise on narrow roads when traffic volumes increases. A Narrow road allows drivers less room to manoeuvre their vehicles and as a result there is less margin for errors than on a wide road

Cross-section improvements measures are listed as follows:

a) constructing road shoulder

b) increasing shoulder width

c) increasing the number of traffic lanes

d) increasing the width of road

e) increasing the width of traffic lanes

f) narrowed traffic lane combined with wider hard shoulder

Road Authorities choose the following measures:

<table>
<thead>
<tr>
<th>Measure</th>
<th>Effect on accidents</th>
<th>Statistically Significant</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase from width narrower than the design standards - rural areas</td>
<td>Increment of all injury accidents</td>
<td>+9</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Reduction of all accidents</td>
<td>-5</td>
<td>Yes</td>
</tr>
<tr>
<td>Increase within road widths permitted by the design standards - rural areas</td>
<td>Increment of all injury accidents</td>
<td>-8</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Reduction of all accidents</td>
<td>-9</td>
<td>Yes</td>
</tr>
</tbody>
</table>
### Increasing shoulder width

<table>
<thead>
<tr>
<th>Measure</th>
<th>Effect on All Injury Accidents</th>
<th>Effect on All Property-Damage-Only Accidents</th>
<th>Cost per Km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing the width of the hard shoulder by about 0.3 metres</td>
<td>-21</td>
<td>Yes</td>
<td>506.971 €/Km</td>
</tr>
<tr>
<td>Reducing all accidents</td>
<td>+2</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

### Increasing the width of traffic lanes

<table>
<thead>
<tr>
<th>Measure</th>
<th>Effect on All Injury Accidents</th>
<th>Effect on All Property-Damage-Only Accidents</th>
<th>Cost per Km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase from width narrower than the design standards - rural areas</td>
<td>-5</td>
<td>Yes</td>
<td>506.971 €/Km</td>
</tr>
<tr>
<td>Reduction of All injury accidents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction of All property-damage-only accidents</td>
<td>-13</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measure</th>
<th>Effect on All Injury Accidents</th>
<th>Effect on All Property-Damage-Only Accidents</th>
<th>Cost per Km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase within road widths permitted by the design standards - rural areas</td>
<td>-8</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Reduction of All injury accidents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction of All property-damage-only accidents</td>
<td>-10</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

Table 8. Information for each measure for Example 1
6.1.2. Example 2

Incident Site: stretch with high accident density
Accident Type: run-off-the-road, overturned and other single vehicle accidents
Cause: Curves, hilltops, vegetation and buildings reduce sight distances at certain points along a road. Reduced and highly variable sight distances make it more difficult to plan driving and give less time to react to unexpected events

According to technical considerations the Road Authorities chose the following measures:

a) improving alignment and sight distances (constructing transition curves)

b) improving alignment and sight distances (increasing distance between horizontal curves)

Road Authorities choose the following measures:

<table>
<thead>
<tr>
<th>Measure</th>
<th>Effect on accidents</th>
<th>Statistically Significant</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improving alignment and sight distances</td>
<td>Reduction of All accidents (unspecified severity)</td>
<td>-10</td>
<td>Yes</td>
</tr>
<tr>
<td>(constructing transition curves)</td>
<td>constructing transition curves</td>
<td></td>
<td>190.114 €/Km</td>
</tr>
<tr>
<td>Improving alignment and sight distances</td>
<td>Reduction of All accidents (unspecified severity)</td>
<td>+10</td>
<td>Yes</td>
</tr>
<tr>
<td>(increasing distance between horizontal curves)</td>
<td>Increasing the distance between horizontal curves by around 50-200 metres</td>
<td></td>
<td>190.114 €/Km</td>
</tr>
</tbody>
</table>

Table 9. Information for each measure for Example 2
7. Conclusions

The questionnaire contemplates factors which give indications about the respondents’ impressions regarding the Expert System SEROES resulting in specific conclusions about the valuation of those aspects.

One of the objectives has been the identification of possible fields of improvement. Subsequently some of the main findings are summarised:

− The general level of satisfaction with the application is above average, standing out as strong points are the simple and clear distribution of the menus, the simplicity of the registration process and the application as a whole.

− On the other hand the precision of the provided information about the measures’ cost-range and the comprehensiveness of the accident scenarios have been identified as fields of improvement.

− Everything related with the applicability and usefulness in real life situations and the output and interpretation of the results are aspects perceived as improvable.

− The majority of the respondents evaluate the functioning in general as positive.

− There was an agreement on the fact that measures which have a “negative” outcome on accident reduction are also included, since misconceptions about the effect of those counterproductive measures are rather popular.

− The fact that the application is only working in English language either wasn’t a problem for most of the users, even though you can suppose that the users who finally worked with the application did so because they had the necessary language knowledge. It was mentioned several times that translated versions would reach a broader target audience, especially under the older road managers.
8. Annexes

Annex 2 Questionnaire

Best Practice Safety Information Expert System SEROES

SEROES the Secondary Roads Expert System offers to the registered user measures to improve secondary roads (paved rural roads) safety.

After the input of a series of data describing an existing road safety problem the application not only offers several solutions, but also a cost-range and information about the effect for each of the provided measures.

The application is directed to road authorities and administrators responsible for secondary roads and is thought to serve as a base of decision making. The system has been especially designed for small and medium road administrations of European countries, with limited financial possibilities. SEROES can be used without much experience in road safety and the collecting and processing of data necessary for a deeper analysis.

With this questionnaire we try to ask about the grade of user satisfaction, the contents and the quality of the provided information to find out where we still can improve the application.

Contact details

Name(s):..........................................................................................................................
Position(s):..................................................................................................................
Telephone: ....................................................................................................................
E-mail: ....................................................................................................................... ...

Information on your Organisation

Name of your organisation: ..........................................................................................

Type of organisation: (mark with an “X”)
Ministry (…)
University (…)
Regional road admin. (…)
Engineering consultant (…)
Regional traffic admin. (…)
Road operator/maintainer (…)
Others (please specify): (…)
About the questionnaire

You will need about 10 minutes to complete the questionnaire. All your data will be treated with the strictest confidence. Please read carefully each statement. Indicate your agreement with each statement on a **scale of 1 - 5**, as set out below.

1. Totally disagree … was unacceptable
2. Disagree … was less than I expected
3. Marginal … this was average …
4. Agree … was above average
5. Totally agree … was excellent

**COMPREHENSIBILITY**

Q 1: I did not have any problems with the registration process since it is easy to carry out and fast.

<table>
<thead>
<tr>
<th>Totally disagree</th>
<th>Disagree</th>
<th>Marginal</th>
<th>Agree</th>
<th>Totally agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>(       )</td>
<td>(       )</td>
<td>(       )</td>
<td>(     )</td>
<td>(        )</td>
</tr>
</tbody>
</table>

Q 2: I have used the help function for the registration process.

Yes No

(     ) (     )

Q 3: SEROES is easy to understanding and self explaining.

<table>
<thead>
<tr>
<th>Totally disagree</th>
<th>Disagree</th>
<th>Marginal</th>
<th>Agree</th>
<th>Totally agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>(     )</td>
<td>(     )</td>
<td>(     )</td>
<td>(     )</td>
<td>(         )</td>
</tr>
</tbody>
</table>
Q 4: The structure of the user interface contributes to the process of understanding the application.

<table>
<thead>
<tr>
<th>Totally disagree</th>
<th>Disagree</th>
<th>Marginal</th>
<th>Agree</th>
<th>Totally agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>

Q 5: The distribution of the menus is simple and clear.

<table>
<thead>
<tr>
<th>Totally disagree</th>
<th>Disagree</th>
<th>Marginal</th>
<th>Agree</th>
<th>Totally agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>

Q 6: SEROES comes in English. I had no problem working with it because of the language.

<table>
<thead>
<tr>
<th>Totally disagree</th>
<th>Disagree</th>
<th>Marginal</th>
<th>Agree</th>
<th>Totally agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>

Q 7: To make SEROES able to be utilised by more possible of users in my country the next version should be available in my language. the language is a barrier.

<table>
<thead>
<tr>
<th>Totally disagree</th>
<th>Disagree</th>
<th>Marginal</th>
<th>Agree</th>
<th>Totally agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>
FUNCTIONING

Q 8: SEROES has 3 menus where you have to choose the incident site, the accident type and the cause. this division serves its purpose.

<table>
<thead>
<tr>
<th>Totally disagree</th>
<th>Disagree</th>
<th>Marginal</th>
<th>Agree</th>
<th>Totally agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>

Q 9: The selection options within the expert system menus consist of succinct descriptions of the input parameter

<table>
<thead>
<tr>
<th>Totally disagree</th>
<th>Disagree</th>
<th>Marginal</th>
<th>Agree</th>
<th>Totally agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>

Q 10: SEROES is easy to use.

<table>
<thead>
<tr>
<th>Totally disagree</th>
<th>Disagree</th>
<th>Marginal</th>
<th>Agree</th>
<th>Totally agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>

Q 11: There are still some options or alternatives missing within the menus.

<table>
<thead>
<tr>
<th>Totally disagree</th>
<th>Disagree</th>
<th>Marginal</th>
<th>Agree</th>
<th>Totally agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>
OUTPUT AND INTERPRETATION OF RESULTS

Q 12: For each measure SEROES provides the objective of the measure, a description and the probable effect on accidents, as well as a statement if this effect is statistically significant or not. This is the information I need to know about a road safety measure.

Totally disagree | Disagree | Marginal | Agree | Totally agree
( ) | ( ) | ( ) | ( ) | ( )

Q 13: SEROES gives information about the cost-range of a measure. I'm interested in this information.

Totally disagree | Disagree | Marginal | Agree | Totally agree
( ) | ( ) | ( ) | ( ) | ( )

Q 14: Even though the information comes in form of a cost-range, it still helps me to form an idea of the approximate costs in my country and to compare measures between each other.

Totally disagree | Disagree | Marginal | Agree | Totally agree
( ) | ( ) | ( ) | ( ) | ( )

Q 15: For my purpose the provided information about the cost-range of a measure is detailed enough.

Totally disagree | Disagree | Marginal | Agree | Totally agree
( ) | ( ) | ( ) | ( ) | ( )
Q 16: In most of the occasions SEROES provides the effect of the same measure for different types of accidents affected. In this way I can choose the type of accident I'm interested in.

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Q 17: Some measures have a “negative” effect on accident reduction, which means that applying this measure will result in an increase of accidents. It's a good idea to show also those counterproductive.

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Q 18: The output of the application is easy to interpret.

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**APPLICABILITY AND USEFULNESS IN THE REAL LIVE**

Q 19: SEROES is meant as a source of information that helps road authorities to choose the best measure for their purpose. The program achieves this aim.

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Q 20: SEROES covers all accident scenarios I need to reconstruct.

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Q 21: SEROES is a tool I could use in my job.

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Q 22: I'm using or will use SEROES to find measures for an existing road safety problem.

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OVERALL IMPRESSION

Q 23: SEROES has an appealing and professional looking design.

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Q 24: The quality of the provided data satisfied me.

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Q 25: The overall impression of the program satisfied me.

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Q 26: SEROES is an important contribution in the road safety field.

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SUGGESTIONS

If you have any further comments, suggestions or remarks please use the space below to write them down. Thank you very much for your cooperation.

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