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Recommendations for Road Safety Impact Assessment

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Recommendations for Road Safety Impact Assessment

Keywords:

Road safety, Road infrastructure project, Road safety measures, Road safety impact assessment.

Abstract:

Road Safety Impact Assessment is an initial part of road infrastructure safety management systems. This report describes the scope of Road Safety Impact Assessment procedures, provides detailed recommendations on qualification of auditors, implementation and execution of procedures for EU member states.

Citation:

Content

Definitions

Road Safety Impact Assessment (RSIA) is a strategic comparative analysis of the impact of a new road or a substantial modification to the existing network on the safety performance of the road network.

“Road safety” is an integrated safety of roads which is determined by the interaction of driver-vehicle-environment subsystems. Road safety aims to reduce damage (deaths, injuries and property damage) resulting from crashes of road vehicles. Best practice road safety strategies focus upon the prevention of serious injury and death crashes in spite of human fallibility.

”Infrastructure project” means a project or plan for the construction of new road infrastructure or substantial modification to the existing network which affects traffic flow or road safety risk factors. Consequently, boundaries of the affected network/territory by infrastructure project should be defined on the basis of traffic or road safety risk factors.

“Safe road design” it is providing road environment which ensures tolerances for vehicle speeds which should be lower for the human serious injury and death probability wherever conflict points exist.

“Construction of new (road) infrastructure” means a type of construction the purpose of which is to do a construction works on a land surface area not occupied by construction works, to rebuild a completely ruined, destroyed, demolished construction works.

“Substantial modification of existing network” or "Reconstruction of existing (road) infrastructure” means a type of construction the purpose of which is to do a reconstruction works (to change load-bearing structures by changing the external dimensions of the construction works – length, width, height, etc.) or significant changes in the traffic organization.

“Designer/Planner” - a person who devises or executes designs/plans, especially one who creates spatial plans, schemes and layouts of roads, structures and detailed drawings.

“Initial designing/planning stage” is planning/designing stage before the infrastructure project is approved or final decisions are taken on implementation of the preferred alternative. Whereas planning and design in some countries are not strictly separated, it is necessary to choose correct word and define “initial designing/planning stage” according to the local regulations.

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1. Scope of RSIA procedures

1.1 What is RSIA?

Road Safety Impact Assessment (RSIA) is a strategic comparative analysis of the impact of a new road project or a substantial modification to the existing network on the safety performance of the road network.

RSIA is a safety management tool that can be implemented by road authorities as a part of an overall traffic safety process.

1.2 What is the purpose of RSIA?

The purpose of RSIA is to demonstrate, on a strategic level, the implications for road safety of different designing/planning alternatives of an infrastructure project. Road safety should play an important role when routes are being selected and safety awareness should be included in the decision making during the designing/planning stage. RSIA is a very beneficial tool that could increase transparency and the availability of information, consequently, it leads the parties concerned to well-informed decisions.

1.3 When should RSIA be done?

Directive 2008/96/EC requires the establishment and implementation of procedures relating to road safety impact assessments, road safety audits, the management of road network safety and safety inspections by the Member States. Directive aims to develop procedures with the aim of increasing safety of road infrastructures (European Parliament, 2008).

Directive 2008/96/EC shall apply to roads which are part of the trans-European road network (TEN) whether they are at the design stage, under construction or in operation.

Road Safety Impact Assessment should be carried out for all trans-European road network (TEN) infrastructure projects. “trans-European road network” means the road network identified in Decision 661/2010/EU of the European Parliament (see Decision No 661/2010/EU of the European Parliament and of the Council, 2010).

Member States may also apply the provisions of Directive 2008/96/EC, as a set of good practices, to national road transport infrastructure, not included in the trans-European road network that was constructed using Community funding in whole or in part.

Road Safety Impact Assessment should be carried out for the project of new construction and reconstruction, i.e. objects having huge influence on traffic flows at the designing/planning stage before the infrastructure project is approved.

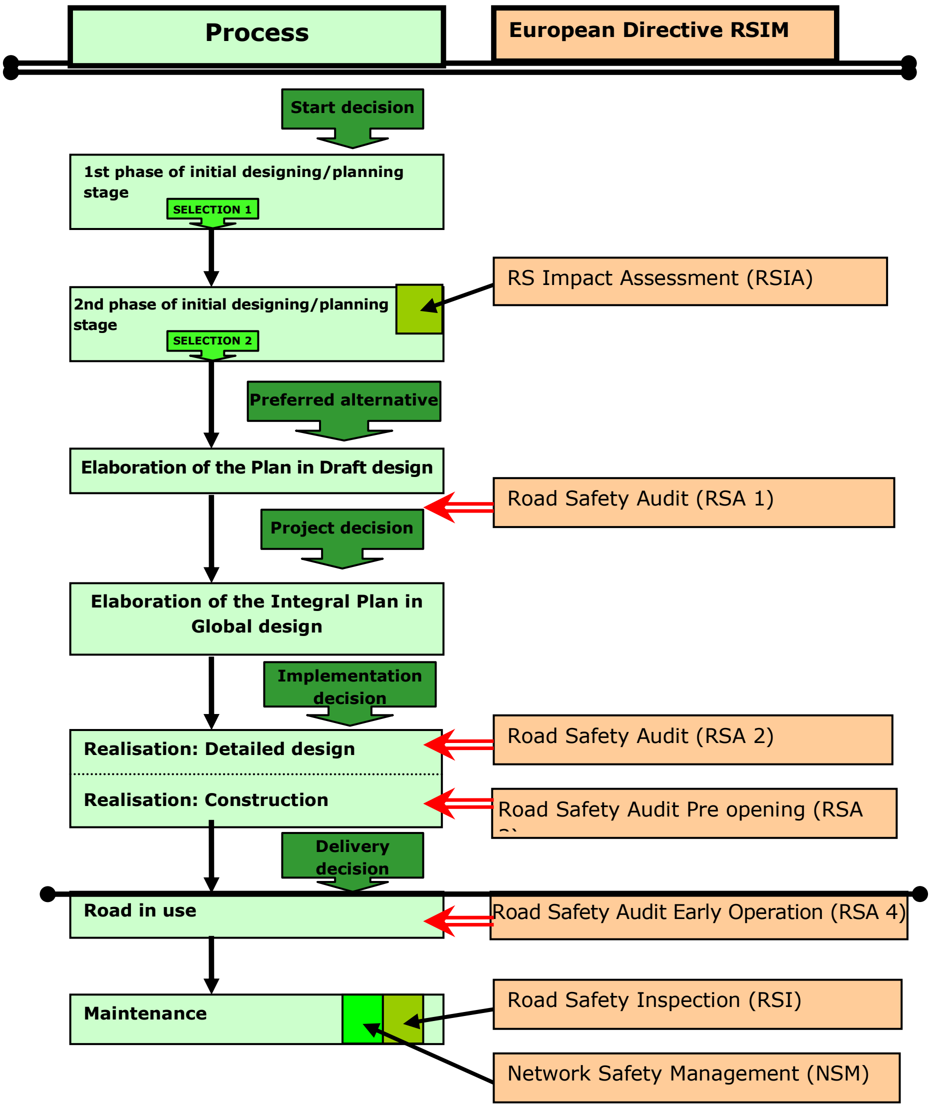

Fig. 1: Explanatory flow chart of road safety infrastructure management (Visit Baltic Sea Region, 2011)

A logical precondition (see Fig. 1) of the procedure of Road Safety Impact Assessment should be planning in all its stages (comprehensive, special, detail plans). The presented flow chart is more

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explanatory therefore, adjustment of such road safety management flow chart to local conditions/particularities would be very practicable.

Road Safety Impact Assessment is produced in parallel with the approval procedure and the designing/planning process of the road.

1.4 Who can carry out RSIA?

RSIA can be carried out by an Auditor, who is a ***neutral legal body*** and independent of the designing/planning team.

Road safety auditors who carry out functions under Directive 2008/96/EC should undergo an initial training resulting in the award of a certificate of competence, and they should take part in periodic further training courses. Certificates awarded before the entry of this Directive into force shall be recognised.

1.5 What is geographical area for RSIA?

Geographical area for RSIA is an infrastructure project and its adjacent area which will be affected by causative changes in traffic flows or risk factors.

1.6 Content

Road Safety Impact Assessment shall indicate the road safety considerations which contribute to the choice of the proposed solution. It shall further provide all relevant information necessary for a cost-benefit analysis of the different options assessed.

1.7 Stakeholders in RSIA

A procedure addresses three parties involved in RSIA who share the responsibility for the whole process:

The client: The organisation responsible for the project which is sometimes also called the project manager, or project sponsor. Often the road authority or local stakeholders are the clients, however, private investors can also be responsible for infrastructure projects. In case of a private investor, prepared documentation (including RSIA report) must be coordinated and approved by the relevant authorities (road authority or local stakeholders).

The designer/planner: A person or team commissioned by the client to develop the road schemes. The designer/planner team can be part of the client's organisation.

The auditor: Expert or team commissioned (or approved) by the client to carry out the RSIA and complying with all the requirements raised by the procedure. In order to ensure an unbiased judgement, the auditor should not to be involved in the design/planning process.

It is necessary to prepare and sign RSIA contract before the start of the project. The contract has to describe the object, financing, timelines and deadlines, what the parties should contribute with and similar information.

1.8 Qualification of Auditors

Road Safety Impact Assessment is an ***independent procedure to assess*** the likely effects of proposed road or traffic schemes, therefore the auditor shall not be involved at any stage in the conception or operation of the relevant infrastructure project. Certificate of competence in the field of RSIA is a prerequisite to perform such audits. It is mandatory to hire a legal body consisting of small auditing team because such auditing team can provide broader and deeper analysis.

Road Safety Impact Assessment (RSIA) should be conducted by road safety expert(s) with a certificate of competence. Certificates awarded before the entry of this Directive into force shall be recognised. RSIA auditors shall undergo an initial training resulting in the award of a certificate of competence, and take part in periodic further training courses. The leader of the audit team should be experienced (at least 5 years) in road designing/planning, road safety engineering and accident analysis, cost benefit analysis and should be properly trained in carrying out such assessments.

The RSIA shall be carried out at the initial designing/planning stage before the infrastructure project is approved, therefore an auditor should have experience in preparation of local designing/planning documents and local designing/planning procedures. Moreover, an auditor shall possess communication skills necessary to present the audit results constructively and encourage a positive response to them from the designing/planning team.

1.9 General requirements and recommendations concerning RSIA procedures

Road Safety Impact Assessments should demonstrate, on a strategic level, the implications for road safety of different designing/planning alternatives of an infrastructure project and they should play an important role when routes projects are being selected. The results of Road Safety Impact Assessments may be set out in a number of documents.

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RSIA procedures are intended to be applied at the initial designing/planning stage with the major aim to prepare definite plan or design of the road network scheme. Procedures should cover two major aspects:

- evaluate impact of planned/alternative network schemes on road safety at the strategic level in the existing network of certain geographical area (entire affected for traffic, but finite network);
- evaluate road safety impact of the existing road network on alternative/planned road network schemes.

Ideally, RSIA could be prepared in parallel to a strategic feasibility study. Usually, such feasibility studies cover traffic forecast, traffic pattern and engineering solutions (route selection, major technical details). The results of Road Safety Impact Assessment should improve the quality of such feasibility study and decision-making: provide all relevant road safety information necessary for a cost-benefit analysis of the different alternatives assessed.

If such strategic studies are not the subject, extra efforts will be needed for RSIA. Deeper and advanced analysis of alternatives might reveal road safety synergies or anti-synergies, however such analysis requires very high skills and expensive tools, i.e. transport modelling, statistical analysis or multi-criteria analysis. Requirements concerning such methodologies may be regulated at national level. For instance, a very detailed RSIA can be performed under favourable circumstances, such as transport models are already running for national/certain territories, or when detailed local studies describe local road safety conditions and its relations to various safety factors.

All in all, the designer/planner should be responsible for data provision, i.e. all initial and essential data needed for the RSIA should be supplied by the designer/planner to the auditor.

Primary analysis

RSIA is carried out for all infrastructure projects which are part of the trans-European road network. RSIA is carried out at the initial designing/planning stage before the infrastructure project is approved. The Member States may also apply the procedures, as a set of good practices, to national road transport infrastructure, not included in the trans-European road network, which was constructed using Community funding in whole or in part.

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The initial steps of RSIA procedures (see Fig. 2) starts from the short description of the plans, topicality of the object including its role in the trans-European network and analysis of local documentation if such exists (comprehensive, special, detail plans).

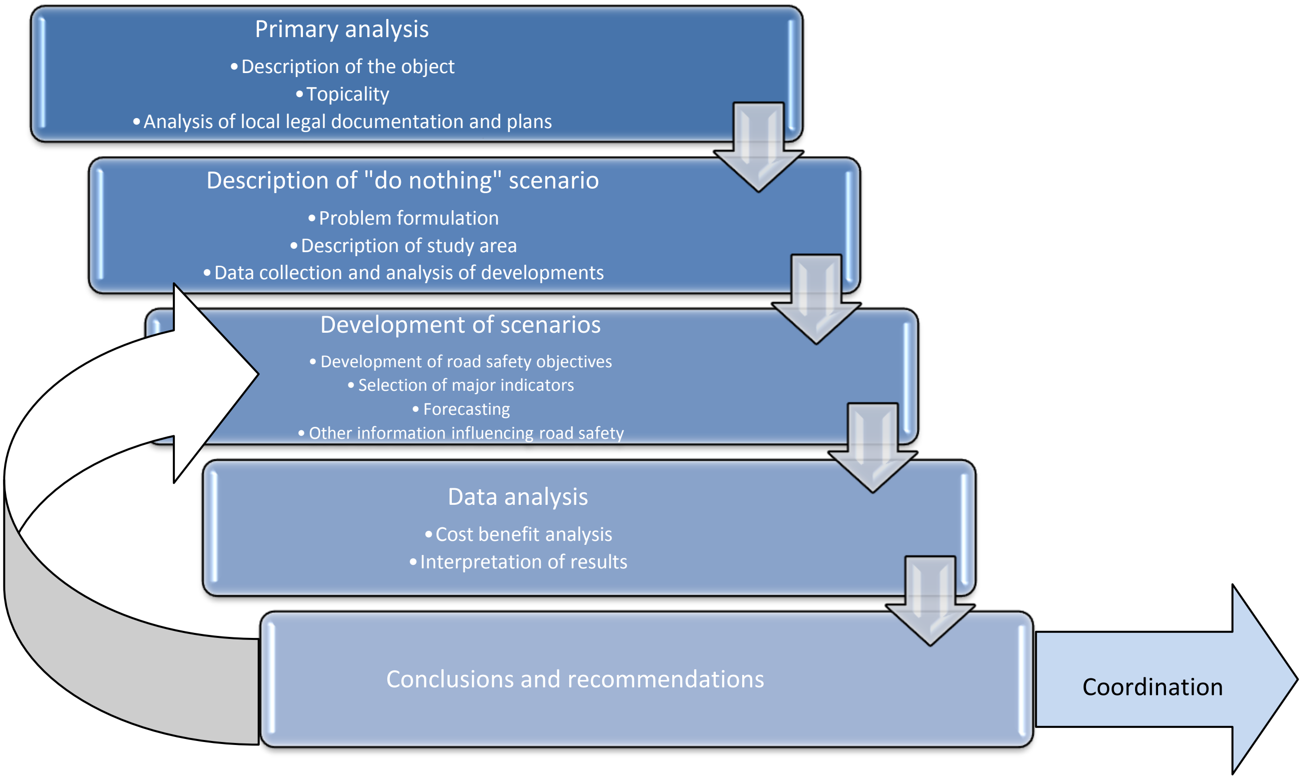

Fig. 2: Flow chart of focal RSIA procedures

Description of "do nothing" scenario

"Do nothing" scenario is an outline for most plausible series of events in the absence of different designing/planning alternatives of an infrastructure project. The question could be formulated as follows: "What would road safety be in the existing ambient infrastructure after certain period of time in the absence of major infrastructure projects?".

Development of scenarios

Road safety objectives could be formulated on the basis of cost-benefit analysis indicators (i.e. cost-benefit ratio, Internal Rate of Return) if there are national methodologies or guidelines. In such way, projects with highest economic indicators would have highest priority (such study covers just a part of feasibility study and indicators).

Effects of road safety elements that are hardly expressed in monetary terms could be evaluated on the basis of selected indicators (effect of road safety element/passenger-km, effect of road safety element/tonne-km, etc.).

RSIA should include at least 2 scenarios (including “*do nothing*”). Scenarios could originate in the designing/planning team (at least one) or in RSIA team. Prognosis of changes in road safety elements could be forecasted by using various methodologies (expert based, analytical, multi-criteria analysis).

Data analysis

This part covers cost benefit analysis for different scenarios, data evaluation and interpretation.

Conclusions and recommendations

This part covers data summarization and interpretation of cost benefit analysis (different scenarios). The RSIA team has a right to propose a new scenario after RSIA process (if the results are not meeting the raised objectives) and evaluate such new scenario among provided scenarios. Similarly, it is possible to construct a new scenario involving strengths of the already evaluated scenarios and to evaluate this new scenario among provided scenarios.

2. Primary analysis

2.1 Description of the object

All necessary initial data for RSIA should be provided by the designing/planning team. Additional data should be collected by using all feasible local sources, i.e. GIS-based systems, local statistical data, etc.

RSIA auditors should characterize such aspects:

- Geographical area;
- Description of client and possessor;
- What is the preliminary schedule of the initial designing/planning stages? (description of RSIA project time-plan and integration into local designing/planning stages);
- What are the constructional plans concerning the infrastructure project? (reconstruction of existing road infrastructure, construction of a new road infrastructure);

- Prepare maps with initial technical specifications of infrastructure project such as category/type/function, length, width, rough investments.

2.2 Topicality

RSIA auditors should describe the following aspects:

- Does the infrastructure object belong to trans-European network? ("trans-European road network" means the road network identified in Decision 661/2010/EU of the European Parliament);

- Member States may also apply the provisions of Directive 2008/96/EC, as a set of good practices, to national road transport infrastructure, not included in the trans-European road network that was constructed using Community funding in whole or in part. In such case the auditors should describe the national reasons and legal base of audit;

- What is the relevance of the object? (more detailed description of corridor, spatial connectivity, modal interactions).

2.3 Analysis of local legal documentation and plans

Although RSIA must be included in the initial planning/designing stages, existing long term planning documentation and plans could be very beneficial. Analysis of local documentation if such exists (comprehensive, special, detail plans) would be helpful to describe the transport and land-use interaction and collect more detailed information concerning the infrastructure project, to validate the project's compliance with local transport policy.

2.4 Description of "do nothing" scenario

"Do nothing" scenario is an outline for most plausible series of events in the absence of different designing/planning alternatives of an infrastructure project.

2.5 Problem formulation

In most cases we assume that road safety could be improved. Therefore, a problem formulation could be in the form of question: What would road safety be in the existing ambient infrastructure after certain period of time in the absence of major infrastructure projects?

A problem formulation can be in the form of the hypothesis: Road safety will be improved in a certain geographical area after implementation of the infrastructure project.

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A *new* road infrastructure could generate negative impact on *local* road safety: generate additional traffic flows and risk factors. In such case RSIA study will not cover all cost-benefit aspects and the problem could be formulated as follows: How can road safety be maximized if major infrastructure projects are implemented?

2.6 Description of study area

Later on, existing affected network/territory must be defined and geographical data should be collected and visualized. The boundaries of the RSIA object (affected network/territory) could be defined on the basis of traffic or road safety risk factors:

- Certain rate of influence of the infrastructure project on traffic (National Road Authority, 2007);
- Certain rate of influence of infrastructure on risk factors.

For instance, RSIA procedure should be implemented in such cases:

- New construction of infrastructure projects;
- Reconstruction of the infrastructure dealing with:
  - Increase of capacity;
  - New entrances or exits;
  - Reorganization of traffic scheme;
  - Substantial road safety improvements (reconstruction of intersections, crossings, installation of road safety improvement packages such as safety barriers, lighting etc.).

2.7 Data collection and analysis of developments

Road Safety Impact Assessments will take place at an early designing/planning stage to allow the results of the assessment to influence the further designing/planning process, as in the case of environmental impact assessment. Land use plans and the pattern of land use in an area can affect the number of accidents by influencing traffic volume, the modal split of traffic, how traffic is distributed between various roads and the accident rate for each road or each mode of transport. Moreover, they will be carried out for all transport policy measures having influence on road safety, including e.g. infrastructure investments, standardisation, pricing etc.

As it was mentioned, all necessary initial data for RSIA should be provided by the designer/planning team. Additional data should be collected by using all feasible sources including GIS-based systems. Modern technologies (i.e. Laser Detection and Ranging) can be used to gather data about existing road parameters and visibility so the decision making process could be done more effectively.

Road Safety Impact Assessment means a strategic comparative analysis of the safety performance of the road network and therefore collection of additional data may vary for "new construction of infrastructure" and "reconstruction of existing infrastructure" cases:

- "new construction of infrastructure projects" – data collection should concentrate on study area including existing ambient infrastructure, i.e. no historical data are available concerning new infrastructure project;
- "substantial modification/reconstruction of existing infrastructure" – data collection should concentrate on study area including all existing infrastructure, i.e. historical data concerning road safety situation on reconstructed object are available.

2.8 Analysis of road function and features

Analysis of national or local territorial planning, national strategies and plans, and legal documentation concerning road designing/planning in the selected area should be done at the first step. Data on road importance in trans-European road network, category of road and analysis of spatial and functional partitioning should be collected.

More detailed description of the infrastructure project in terms of topicality should be accomplished: linkage to TEN or national transport corridors, analysis of national road network development programme, description of project objectives (traffic accident rate reduction, reduction in travel time, etc.). Describing the needs of the project, the following data should be analyzed:

- technical Building and Territory Planning Regulations and Laws, the European Union documents that define requirements for technical solutions (if necessary);
- new construction or reconstruction;
- type of infrastructure object (road, bridge and so on), location (start point, end point, width), spatial connection to other objects;

- current and future technical category and function (role in hierarchy, main structure of the road pavement, the transverse profile);
- current technical condition of the object (the object construction defects, their quantity and size);
- factors influencing the need of the project (completion of road network, traffic growth, risk factors etc.). The impact of the project on development of road network and transport infrastructure at national and international context, taking into account the current needs and perspective;
- current road environment and location (built-up area or undeveloped area; residential, administrative, economic area, localization next to strategic objects, fields, farmsteads, and so on.);
- if information available: road alignment, coordination of elements of plan and longitudinal profile, geometric design and other features influencing sight distance and quality of road perspective picture, visually received by drivers;
- determine whether the road is available/intended for public transport, analysis of public transport infrastructure should be performed.

2.9 Accidents

Describing the impact on road safety, the following data should be analysed:

- completeness of road safety measures on existing road network;
- accidents that have occurred over the past 5 years or more (considering accident severity):
    - accidents with fatalities;
    - accidents with injuries;
    - accidents with damages;
    - determine the predominant types of accidents and contributing factors;
    - determine how many drivers exceeded the speed.

2.10 Traffic patterns, volume and categorization

Traffic volumes (AADT) and road lengths are the most important variables in accidents prediction. Data collection scope, if data available, is as follows:

- uninterrupted flow or interrupted flow;
- speed demand and restrictions;
- intersections and their types;
- slip roads; pedestrian and bicycle paths, sidewalks;
- volume of traffic, vehicle kilometres, passenger kilometres, tonne kilometres;
- traffic composition.

2.11 Road users (including vulnerable users)

Describe how does infrastructure fits the needs of the following road users:

- pedestrians and cyclists (moving along the road and crossing the road, needs of the disabled people);
- motorcyclists;
- public transport;
- public transport stops, infrastructure, passengers separation from the main flow, accessibility for the disabled people;
- freight transport;
- cars;
- condition of roadside.

2.12 Seasonal and climatic conditions

Safety of traffic flow is strongly influenced by climatic conditions and therefore there is need to examine areas of flooding, road de-icing, and snowbound threats and what are the possible consequences for the traffic safety because of these extreme climatic conditions in the planned territory.

Presence of a sufficient number of safe parking areas

Data needed on traffic safety:

- long-term stops, their separation from the traffic flow;
- short-term stops, their separation from the traffic flow;
- the possibility of emergency stop in the event of a breakdown or traffic accidents.

2.13 Seismic activity (where it is applicable)

Seismic activity must be evaluated in the target area. Data should be collected on the possibility of occurrence of seismic activity and should be focused on the - how often earthquakes occur in the planned area, magnitude of seismic activity, what the possible consequences of seismic activity for traffic safety in the planned area.

2.14 Other information influencing road safety assessment

Data on land use and future land use developments are very essential for the forecast of future spatial interactions in the territory. A spatial interaction is a realized movement of people, freight or information between origin and destination. Data on land use should include at least the most important socio-economic variables pertaining to the area under investigation, such as population, employment, income level, commercial activity, etc. Such data is used to estimate or calibrate the amount of travel generated and attracted (origin and destination), however further forecast could be based on various methods (expert based forecasting, simple calculations or traffic modelling).

Auditors should pay attention to intermodal or multimodal interaction in the territory if such exists or is foreseen. Many economic and transport activities as generally located at hubs, including distribution, warehousing, finance and retailing. Intermodal and multimodal interactions could cause the need of special infrastructure and generate additional transport needs and flows. With economic development, the addition of new activities and transport infrastructures, spatial interactions have a tendency to change very rapidly as flows adapt to a new spatial structure.

Various local conditions such as geological (i.e. karst), hydrological and suchlike conditions could affect road safety too, therefore auditors should cover such aspects.

In regard to smaller details, moderate attention could be paid to road lighting (percentage of lighted road length), wild life crossings and road fencing, roadside obstacles, railway crossings.

Road construction is usually most cost-effective when there is a high traffic volume and severe problems connected with traffic (high risks, congestion and environmental problems). Additional information would be useful for the cost benefit analysis:

- direct losses of an accident, monetary evaluation of killed or injured person;
- project risk factors and their significance.

3. Development of scenarios

RSIA should include at least 2 scenarios:

- "*do nothing*";
- "*do project*".

Scenario "*do project*" in most of the cases will originate in the designing/planning team, but RSIA team has a right to propose a new scenario after evaluation if the results do not meet the raised objectives and evaluate this new scenario among the provided scenarios. Similarly, it is possible to construct a new scenario involving strengths of the already evaluated scenarios and to evaluate this new scenario among the provided scenarios. All the scenarios must be calculated with the same method.

3.1 Development of road safety objectives

The primary goals of RSIA related to road safety objectives are:

- strategic aspects of road safety are incorporated in the initial designing/planning stage before the infrastructure project is approved;
- consider all reasonable alternatives and lead project to optimal solutions;
- reveal road safety uncertainties and gaps, which should be covered in later planning and designing procedures.

National authorities and clients have a right to set up specific objectives, however it doesn't guarantee absolute outcomes in a long term perspective.

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3.2 Selection of major indicators

There are a number of methodologies how to evaluate performance of transport infrastructure: cost/efficiency, cost-benefit, life-cycle, least cost planning, multi-criteria analysis and combined adaptations of such methodologies. Cost benefit analysis for life-cycle of infrastructure project is one of the most common analysis and normally based on local adaptations. Three separate measures are usually obtained from a cost benefit analysis to aid decision making:

- Net Present Value (NPV): It is obtained by subtracting the discounted costs and negative effects from the discounted benefits. A negative NPV suggests that the project should be rejected because the society would be worse off.
- Benefit-cost ratio: It is derived by dividing the discounted costs by the discounted benefits. A value greater than 1 would indicate a useful project.
- Internal Rate of Return (IRR): The average rate of return on investment costs over the life of the project.

In such way, projects with highest economic indicators would have highest priority (RSIA study most likely will cover just a part of feasibility study and its indicators).
Studies dealing with strategic aspects should deal with long term periods such as 15-30 years horizon. However, amendment to the horizon could be based on local methodologies.
Effects of road safety elements which are hard to express in monetary terms could be evaluated on the basis of selected indicators. Primary traffic indicators could be:

- Passenger kilometres;
- Vehicle kilometres;
- Tone kilometres.

These indicators could be selected considering available information. Later on, indicators should be calculated as relative indicators:

- effect of road safety element/passenger kilometre;
- effect of road safety element/vehicle kilometre;
- effect of road safety element/tone kilometre.

Effect of road safety could be measured by decrease in the number of fatalities, accidents, risk factors or even monetary expressions of these and other benefits.

3.3 Forecasting

Forecast should be performed for all prepared scenarios. For instance, if RSIA includes "*do nothing*" and "*do project*" scenarios, the arrangement for further research should be as follows:

- "*do nothing*" after certain period of time (15-30 years);
- "*do project*" just after implementation;
- "*do project*" after a certain period of time (15-30 years).

3.4 Forecast of accidents

What would be accident rate after a certain period of time for each scenario?

Most of the European countries have already prepared or are preparing methodologies concerning accident forecasting. In this way, countries can use their own methodologies. Please note, that further methodologies and models are illustrative examples only, as the development of national methodologies and models is a time consuming and costly process.

However, short overview of methodologies how to predict accidents would be helpful for the countries starting up the RSIA. Basic methodologies used to predict future developments are:

1. Expert opinion is based on expert's experience concerning influence of infrastructure project on road safety;
2. Analytical methodology is based on simple mathematical calculations of road accidents (per road type and traffic volume) on existing roads and use of such data to predict future situations on designed/planned infrastructure;
3. Statistical modelling is based on statistical road accident analysis and development of accident prediction models considering road type, traffic volume, speed limit and etc. Use of the Bayesian method is recommended as the best practice;
4. Multi-criteria decision making is based on in-depth analysis of road safety criteria/elements and their interaction.

Assessment by experts is a simple procedure and will definitely guaranty an outcome, however validity and reliability are questionable.

National analytical methodology could consist of the following major steps (Wegman et al., 1994; European Transport Safety Council, 1997):

1. Basic data analysis at national level:
    a. Categorizing a road network;
    b. Road safety indicators per type of road (i.e. average of 5 years);
    c. Relationship between road safety indicators and primary traffic indicators;
    d. Distribution of road safety indicators;
    e. Development of road safety indicators.
2. Research of certain geographical/study area in reference year:
    a. Roads per road type;

   b. Traffic volumes per road type (i.e. average of 5 years);
   c. Accidents per road type (i.e. average of 5 years);
   d. Road safety indicator per road type;
   e. Comparison of national and regional road safety indicators.
3. Research of certain geographical/study area in future year:
   a. Road network per road type and estimations of traffic volumes;
   b. Estimations of road safety indicators;
   c. Estimation of road safety effects.

Statistical modelling gives mathematical formula describing the relation between the safety level of existing roads and variables that explains this level. Ripcor-Iserest projects deliverable "Accident Prediction Models and Road Safety Impact Assessment: Recommendations for Using these Tools" describes a modern accident forecast model as (Eenink et al, 2008):

$$E(\lambda) = \alpha Q_{\mathrm{MA}}^{\beta} Q_{\mathrm{MI}}^{\beta} e^{\sum \gamma_i x_i}.$$

The estimated expected number of accidents, $E(\lambda)$, is a function of traffic volume, Q, and a set of risk factors, x_i $(i = 1, 2, 3, \ldots, n)$. The effect of traffic volume on accidents is modelled in terms of an elasticity, that is a power, β, to which traffic volume is raised. For intersections volumes for the major and minor road are included. The effects of various risk factors that influence the probability of accidents, given exposure, is generally modelled as an exponential function, that is as e (the base of natural logarithms) raised to a sum of the product of coefficients, γ_i, and values of the variables, x_i, denoting risk factors.

Practical tools have been developed to standardise and simplify accident evaluations. One example of them is TARVA – a tool for evaluating reliably the existing safety situation as well as expected effects of various safety measures. It uses local road and traffic information together with international best practice information about the results of road safety studies.

An accident model TARVA has originally been developed for Finnish roads (database and language), but even the English version with Lithuanian road data base and accident models has been produced (TARVAL). Because of simple evaluation algorithms, the programme can easily be converted to any other country that has some basic database about roads, traffic and accidents.

The safety effects of infrastructure improvements can be evaluated easily and using the same data and definitions for all the roads in the database. The minimum input is: i) what is the measure and ii) where it is implemented. In Finland, there are almost 100 predetermined measures in the programme and own measures can be defined by the user if needed. Also the implementation costs can be entered but the average costs for measures (per km or per measure) are used, if these values are not entered.

The estimation of safety effects (see figure 3) of road improvements in TARVA is a four-phase process (Peltola, 2000):

1) For each homogeneous road segment the most reliable estimate of the accident number is combined from the number of accidents in the past, vehicle mileage and the average accident rate in corresponding conditions. Accident information is combined in a formula which takes into consideration the model's goodness of fit and the random variation in the number of accidents. The weight of the accident model compared to the weight of the accident history is the bigger the more there is random variation in the accident count.

2) To make prediction of the number of accidents without road improvements the most reliable estimate of the number of accidents is corrected by the growth coefficient of the traffic. Also the effects of fundamental changes in land use on the forecasted accident number can be taken into consideration by the coefficient.

3) The effects of measures on injury accidents are then described in terms of impact coefficients. The impacts coefficients have been obtained from the research results of all the relevant countries taking into consideration the differences in traffic regulation and road user behaviour.

4) Road improvement measures can affect also the severity of the accidents remaining on the road after the improvement. These effects can also be taken into consideration in TARVA by using severity change coefficients.

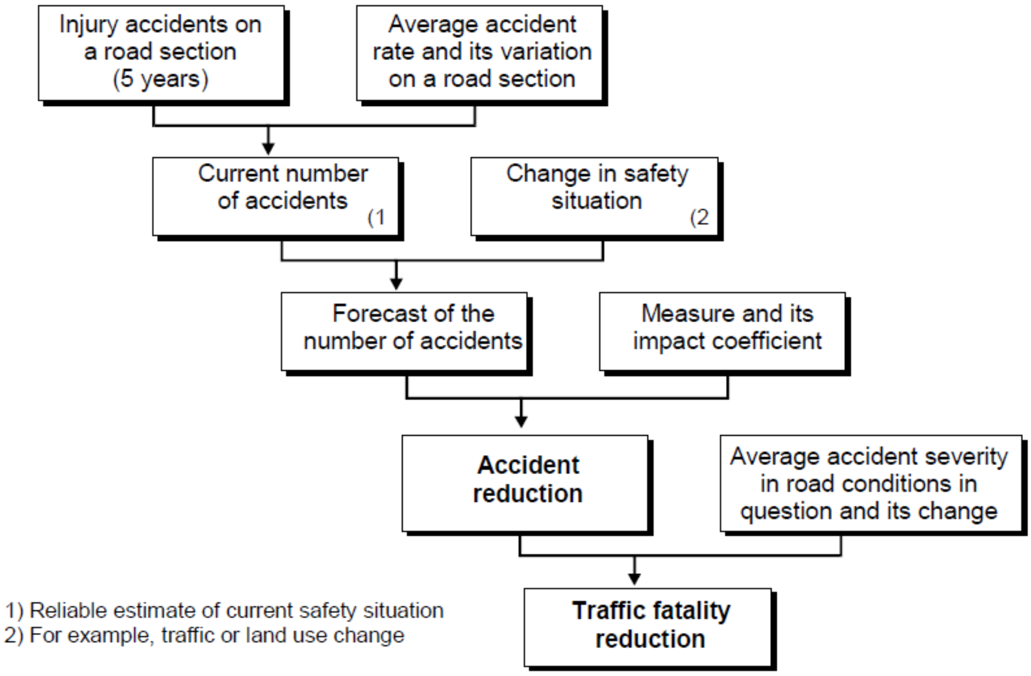

Fig. 3: Flow chart of TARVA processes (Peltola, 2000)

Using evaluated injury accident reduction percentage and knowledge about the average severity (deaths/100 injury accidents) and its change, TARVA gives an estimate of yearly-avoided accidents. TARVA uses different models for junctions and road sections. For road sections, the accident prediction model is based on the number of accidents per vehicle mileage and for junctions on the number of accidents per incoming vehicles. Model calculates three separate types of accidents (those involving motor vehicles only, involving pedestrians and bicyclists and involving animals). These are used because road improvements can have very different effects on those accident types.

Using the estimates of yearly avoided injury accidents and fatalities due to road improvements, one can easily calculate savings in accident costs. When knowing also the costs of the measures, it is easy to calculate what kind of measures is the most effective regarding safety and where those measures pay off most effectively.

There are also other more evaluation tools/models of such kind, like the ones for analysing the accidents in more details – an example of this is ONHA-tool (Lithuanian and Finnish accident databases in Lithuanian, Finnish and English languages). Another kind of tool would help in evaluating the safety effects of different kinds of road safety measures when preparing national road safety plans – again an example of this if instance TEPA – used in Finland and ONHA.

All these tools are useful for national evaluations, but extra benefit can be achieved from the possibility to carry out international comparison.

Multiple-criteria decision making or multiple-criteria decision analysis refers to making decisions in the presence of multiple criteria. Application of multiple-criteria decision making methods in planning is not a new thing. As an example, under the European Union Road Safety Action Programme 1997-2001 a multi-criteria analysis of the various safety actions was followed by a cost-effectiveness analysis leading to the definition and ranking of short- and medium-term road safety priorities in the European Union (OECD, 2002).

Nowadays, a multi-criteria decision making framework for road safety research aims at incorporating advanced statistical methods (such as optimization algorithms) into a new multi-criteria decision making framework in order to enable road safety decision makers to make better informed choices. Given the complexity of the road safety phenomenon and the increasing attention paid to an extended set of road safety indicators (in which not only the number of fatalities are included, but also risk factors, policy efforts and descriptive characteristics), evaluation based on multiple indicators is required. Consequently, to measure the multi-dimensional concept of road safety which cannot be captured by a single indicator, the exploration of a composite road safety index is attractive and desirable. Compared to other fields such as environment, economy, and society, the development of a composite index for road safety is relatively new and promising (Qiong Bao et al., 2010).

All the scenarios must be calculated with the same method.

3.5 Route choice and traffic patterns, volume and categorization

RSIA study requires transportation forecasting. Transportation forecasting is the process of estimating the number of vehicles or people that will use a specific transportation facility in the future. For forecasting some countries use a fixed time traffic growth rate expressed in units or percents per year. As it was mentioned, RSIA could be prepared in parallel to a strategic feasibility study. Usually, such feasibility studies cover route choice and traffic patterns, volume, categorization, aspects. In the case of the absence of such feasibility studies, transport modelling software (i.e. Emme/2, Cube , PTV VISION etc.) can be used for transport forecasting and data analysis. Thus, RSIA study should answer such questions for each “*do project*” scenario:

- Does a new infrastructure project make influence on route choice and traffic patterns?

- How much does a new infrastructure project make influence on route choice and traffic patterns?

- What would the distribution of traffic volumes in the whole network be after implementation of infrastructure project?

- What would the influence of new infrastructure project on the structure of traffic be (vehicle categories)?

The "*Do nothing*" scenario after a certain period of time should be described by expected traffic volumes and vehicle categories.

3.6 Possible effects on the existing network elements (e.g. exits, intersections, level crossings)

A large part of accidents occurs on road junctions, such as exits, intersections and level crossings. For this reason, it is necessary to prepare more detailed analysis and to take into account the changed traffic conditions on major junctions:

- What would the accident and fatality rate be on junctions after a certain period of time for the scenario?

Road users, including vulnerable users (e.g. pedestrians, cyclists, motorcyclists)

Infrastructure and conditions of movement for vulnerable users is very important for the road safety level.

- Are vulnerable users' flows sufficiently separated (under the circumstances) from other traffic flows (footpaths, crossings, special attention to public transport stops)?

- Are there additional road safety measures in the conflict points with the vulnerable users?

3.7 Seasonal and climatic conditions

Various extreme regional seasonal and climatic conditions could affect road safety. RSIA study should answer such questions for each scenario:

- Is there any possibility that extreme regional climatic conditions influence road safety?

- If yes, does infrastructure project minimize influence of such regional climatic conditions on road safety?

- What additional measures would be recommended?

RSIA should give clear recommendations what effects of extreme regional conditions should be covered/tackled in further planning and designing stages.

3.8 Presence of a sufficient number of safe parking areas

A well-equipped place for long-term and short-term stops for rest helps to prevent stopping in the roadside or avoid tired drivers on the roads.

- Are there enough parking areas for long distance drivers to stop and rest? Are they separated from the general traffic flow?

- Are the gaps between short-term stops not too long and the drivers are not forced to stop in the roadside? Are they separated from the general traffic flow?

- Is there a possibility for emergency stop in the event of breakdown or traffic accident?

3.9 Seismic activity (where it is applicable)

The seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Very frequent seismic activity and its effects (landslides, avalanche, rock fall, etc.) could affect road safety. RSIA study should answer such questions for each scenario:

- Is there any possibility that seismic activity and its effects could influence road safety?
- If yes, does infrastructure project minimize influence of seismic activity and its effects on road safety?
- What additional measures would be recommended?

RSIA should give clear recommendations what effects of seismic activity should be covered/tackled in further planning and designing stages.

3.10 Other information influencing road safety

Data on land use, intermodal or multimodal interaction should be used to forecast traffic volumes and predict intersection/conflicts of various transportation modes (road transport, pedestrians, cyclist and other vulnerable users). The major question here: are there any land use changes foreseen that could have influence on traffic flows and road safety?
Various local conditions such as geological (i.e. karst), hydrological and suchlike conditions could affect road safety. RSIA study should answer such additional questions for each scenario:

- Is there any possibility that various local conditions influence road safety?

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- If yes, does infrastructure project minimize influence of such local conditions on road safety?
- What additional measures would be recommended?

RSIA should give clear recommendations what effects of local conditions should be covered/tackled in further planning and designing stages.

RSIA study could evaluate smaller details if there is information on road safety elements such as road lightning, wild life crossings and road fencing, roadside obstacles, railway crossings.

4. Data analysis

4.1 Cost-benefit analysis

Cost-benefit analysis should be conducted according to valid local methodologies or guides to cost-benefit analysis (European commission, Directorate General Regional Policy, 2008; SafetyNet, 2009). Major steps of cost-benefit analysis are:

- Description of each scenario;
- Define cost and benefit elements for further analysis;
- Define measurement units and monetize such units;
- Define discount rate;
- Calculation of yearly benefits and costs (i.e. 15-30 years);
- Calculate net present value, benefit-cost ratio, internal rate of return;
- Define elements which are hardly expressed in terms of money;
- Perform sensitivity analysis;
- Prepare results (graphs, tables, matrices, summary).

4.2 Interpretation of results

The results of the study should meet the raised objectives and consider all relevant factors affecting the problem to avoid false generalization.

Interpretation is an art that one learns through practice and experience. It should be stressed that much prudence is needed in the interpretation of the analysis results. It is advisable, before embarking upon final conclusions, to consult the auditing team members who will not hesitate to point out omissions and errors in logical argumentation. Eventually, the team leader must give reasonable explanations of proposals and present proposals to all parties concerned (client and designer/planner).

5. Conclusions and recommendations

This part covers summarization and generalization of the cost-benefit analysis data and other elements of RSIA (including all different scenarios). RSIA team has a right to propose a new scenario after RSIA process (if the results do not meet the raised objectives) and evaluate such new scenario among provided scenarios.

Similarly, it is possible to construct a new scenario involving strengths of the already evaluated scenarios and to evaluate this new scenario among the provided initial scenarios.

Finally, auditors should prepare and sign RSIA report.

Coordination

The proposals of the auditing team should be presented (provide report and/or prepare oral presentation) to the designer/planner and client in order to find the final consensus concerning infrastructure project. Designer/planner and client have a right to submit comments in written and/or oral form. The report of Auditors could be updated and adjusted after the meeting with other parties. However, the Client makes final decision whether recommendations are to be adopted or not. The written response to the audit report from Client is a part of the RSIA project documentation.

Recommendations concerning use of prepared material

1. RSIA is a tool that could increase transparency and awareness of decision making during initial designing/planning process. It is useful tool to develop and compare policy options, though it requires high quality databases, preferably based on latest technologies such as GIS.

2. RSIA procedures is an integral part of the designing/planning process of the infrastructure project at the stage of initial designing/planning in the EU member states. Some EU members already possess the well functioning road infrastructure safety management systems. These countries are permitted to continue using their existing methods, in so far as they are consistent with the aims of Directive 2008/96/EC.

3. The prepared RSIA procedures are recommendatory and should be adapted to local conditions and peculiarities. Special attention should be paid to local adjustment of the section “Definitions”.

4. Structure of the RSIA report should consist of such key-sections: Primary analysis, Description of "do nothing" scenario, Development of "do project" scenarios, Data analysis, Conclusion and recommendations. Hence, various methods can be used during preparation of these sections, therefore prepared recommendations provide short overview of methodologies that are useful for the countries starting up RSIA.

5. National road accident forecast models are the part of RSIA methodology and such models should be developed for different road types. Simple road accident models estimate dependency between the number of accidents and traffic volume. More sophisticated models evaluate safety effects of various road infrastructure improvements; however such models require significant need for data, know-how and financial recourses.

6. Development of national road accident forecast models is a responsibility of national entities (i.e. road authorities). It is evident, that cooperation between national authorities and research organizations is a prerequisite for the development of sophisticated models.

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