The wildlife aspect in the linear transport infrastructure development processes

Maros Finka¹, Milan Husar¹, Vladimir Ondrejicka¹, Lubomir Jamecny¹

¹Spectra Centre of Excellence of the EU, Slovak University of Technology in Bratislava, Vazovova 5, 812 43 Bratislava, Slovakia

milan.husar@stuba.sk

Abstract. The Carpathian Mountains present some of the most preserved natural habitats for wildlife species in Europe. These natural environments provide a great number of ecosystem services for the whole Europe and their protection is in the interest of all stakeholders in the territory, from the local and regional state authorities, NGOs and private sector actors. Many regulations in form of the various formal and informal documents exist and these are different from country to country which creates one of the key issues when protecting this vast natural area. The unified system of protection recognized in all Carpathian countries is rather missing and for this reason the Framework Convention on the Protection and Sustainable Development of the Carpathians (Carpathian Convention) had been formed with an objective to foster the sustainable development and the protection of the Carpathian region. One of their activities is to support the legal procedures aimed at protecting the Carpathian Mountains and INTERREG-supported TRANSGREEN and CONNECTGREEN project is one of its main activities, of which this paper is one of the main outputs. The objective of this paper is to clarify how and where the wildlife aspects have to be integrated in the general process of the linear transport infrastructure development processes within Carpathian countries.

1. Introduction
The most efficient way, how to avoid or minimise the conflicts and negative effects of the transport on the wildlife is to reflect the needs to protect the wildlife already in the processes of the transport infrastructure development, including the planning.

The effects of the transport infrastructure development on wildlife and potentials for their minimizing differ depending on
• the transport mode (car transport, pedestrian transport, bicycle transport, railways, air transport, cable lines, pipelines, waterways and channels),
• the state-of-art contexts (availability of the transport infrastructure and its features, landscape features, modes of use of the territory) and
• particular elements of the transport infrastructure (transport road, parking, service infrastructure).

This paper focuses on the development process of road and railway linear infrastructure, but described principles, approaches and tools are applicable to other transport modes and particular elements.
2. Processes of the linear transport infrastructure

The lists and description of the whole scale of approaches, methods and instruments within this paper are linked to the development process of the roads and railway lines as the timeline and content framework for the synergies between different tools. It creates a practical co-existence “road” map issues of ecological and economic/social development demands in the overall area with a general approach. This is very important not only for analysing and putting together the “green infrastructures map” with the “grey infrastructure map” including existing infrastructures and the new linear one that has to be built in connection of all legal and administrative needs. It is of special importance to see and to understand the general cumulative impacts on nature-environment-wildlife and to decide on the priorities in the hierarchy: Avoidance – Mitigation – Compensation.

At the same time, embedding the approaches, methods, and instruments in the phases of the transport infrastructure development we can clearly see the necessity of multidisciplinary approach and working together between politicians, technicians, engineers, economists, landscape designers and environmentalist and the need of active involvement of stakeholders in each phase.

The linear transport infrastructure process, independently from modifications, includes common logic of steps starting with the scoping, via planning, designing, construction and operation/maintenance, and monitoring (figure 1).

![Figure 1. Linear transport infrastructure processes](image)

Each step/phase can be characterised by

a. The content of the steps/phase
b. The problems/challenges to be solved in relation to the wildlife protection in a respective phase/step
c. Advised approaches, tools and measures to be used in the reflection of identified problems/challenges
d. The stakeholders relevant for engagement in respective step/phase

The content of respective phases of the transport infrastructure development has a common base which varies to a certain extent depending on the decision based on the demand, limits and possibilities identified in the phase of scoping. The identified demand can be covered by 3 different modes of transport infrastructure development characterised as:

1. The development of new roads and railway lines or their parts
2. The update of existing roads and railways (modernising, extension in former corridors, increase of capacities, speed)
3. The improving ecological status of existing routes and railways

The basic content modifications the in respective phases can be summarized in the following overview (figure 2):
According to the type of construction (development of the new infrastructure, updating the existing roads and railways or improving the ecological status of existing infrastructure), the processes of infrastructure construction are different (figure 3, figure 4 and figure 5). More detailed can be found in Finka et al [1].

These differences are mirrored in the structure of the following sub-chapters bringing the description of respective steps/phases (see also table 1 and table 2).

In the respective phase, different tools are used for harmonising transport corridors and wild animals’ migration corridors. The tools include processes and to the associated actions, documentation and legal acts with indirect effects and measures as the implementation actions, technical and environmental solutions with direct effects on ecological quality of linear transport infrastructure especially safety and permeability for wild animals.

2.1 Phase 1: Scoping
The phase of scoping is focused on the identification/definition of qualitative and quantitative demands on transport performance, quantity and quality of their satisfaction by existing infrastructure, conflicts between existing infrastructure and other interests in the territory, especially wildlife protection and analyses of technical, technological, economic and other framework preconditions/possibilities for the respond on the demand. This phase, called as fore-investment phase, has to prepare all relevant data for the strategic planning phase, especially for the decisions

- to develop/not to develop transport infrastructure,
- on the transport system which will cover the transport performance need
- on the development mode (new, update, improvement) and
- on qualitative and quantitative parameters of the development.

In case of clearly formulated requirement to construct a new transport infrastructure, the content of scoping phase is narrowed on the performance demand definition and identification of the framework
preconditions as the basis for the definition of qualitative and quantitative parameters of the given transport infrastructure. The part of this phase used to be an elaboration of a study / set of specialised studies analysing different possibilities to cover identified demand. The output of the scoping phase is the decision about the investment – investment intention.

In the process of update of existing roads and railways lines is predominantly motivated by the demand to improve their transport performance via changing their parameters determining the speed of transport flows, the capacity of the flows, the resilience of the infrastructure, safety. In this context, the phase of scoping is focused on the identification/definition of qualitative and quantitative demand on transport infrastructure and its improved/extended performance in given transport corridor and analyses of technical, technological, economic and other framework preconditions for the response on the up-date demand.

The development of linear transport infrastructure via improving the ecological status of existing routes and railways is a specific case of an update of the infrastructure. As in some cases, the efficiency of particular technical interventions implemented directly on the road/railway line depends on supportive interventions in a broader area, the process of improvement of the ecological status of existing routes and railways has to include the planning and implementing the ecologic, managerial and organisational intervention in a broader area. This requirement influences already the scoping phase framed by changes in the societal priorities in the direction towards environmental values and motivated by the necessity to safeguard sustainability via protecting the wildlife and the living environment.

2.2 Phase 2: Planning
The phase of strategic planning is a crucial decision-making phase the outputs of which are the decisions about:

- **What** – transport system covering the transport demand (e.g. whether to build a road or a railway),
- **How** - the category of the transport infrastructure and transport capacity and basic features/parameters of the linear transport infrastructure
- **Where** - The definition of the transport corridor (strategic planning – routing the corridor and strategic environmental assessment)

The phase of planning can be divided into two levels

- **strategic planning** setting main goals, principles, parameters including principal placement. A typical feature of this level of planning (especially in regard to the development of new roads and railway lines or their parts) is the strategy development and strategic decision making working with alternatives. The comparison of different alternatives allows a better understanding of possibilities, limits and optimal solutions. The phase of the strategic planning uses to be closed by the strategic decision about constructing new linear transport infrastructure including the definition of its basic location. This strategic decision has got in different countries different legal position and form. The overall level used to be represented by the approval of the land-use planning documentation. The lower level used to have the form of the decision about placement of investment (e.g. territorial decision) including binding precondition for projecting and construction design. The background for this decision creates the documentation for the territorial decision. An inherent part of the strategic planning and strategic decision-making process is a strategic environmental assessment (SEA) [2].

- **detailed planning** including precision of the main features of the developed transport infrastructure following the frames defined at the level of strategic planning. The detailed planning creates the basis for designing followed by final decision usually in the form of building permission. The
basis for the building permission process is the documentation for the building permission and the statements of all relevant representatives of public interest – state bodies, organisations responsible for public infrastructure management, nature conservation, etc.

2.3 Phase 3: Projecting

The phase of projecting is focused on construction design and detailed elaboration of the projects for the particular elements of the road/railway line in the corridor already defined in the phase of planning. The border between planning and projecting phase is fuzzy. The elaboration of the documentation for building permission continues in the elaboration of detailed documentation for the procurement of the construction work and construction itself.

This phase builds on
- previous planning phase including the analytical work,
- a strategic environmental assessment (SEA)
- basic requirements resulting from the strategic phase of decision making and
- detailed data about the technologies and resources available
- detailed data about the environment of implementation

Based on defined and in detail identified problems, threats and challenges the proper solutions at the level of projecting and construction designing are proposed and elaborated. The output of this phase is detailed project documentation which is the basis for the building permission and for realisation.

An inherent part of the phase of the projecting and construction design is the process of environmental impact assessment (EIA). The EIA process used to be linked to the previous strategic environmental assessment (SEA) process. If it is not done as a part of the planning and SEA process, the phase of projecting and EIA process develops within the selected corridor different variants. These variants are compared in a cost-benefit-analysis evaluating technical, environmental and financial aspects. The result is a decision for the overall best option. Concerning ecological aspects most emphasise is put on AVOIDANCE1.

The EIA focuses on a detailed assessment of the proposed technical and technological proposal for the construction and operation of particular elements of the linear transport infrastructure as well as on mitigation measures in respect to the not avoidable negative impacts of the transport infrastructure development. The whole transport lines used to be divided into smaller segments and assessed with a special focus on detailed parameters of the segments and parts of infrastructure as well as on detailed parameters of the measures lowering or mitigating connected impacts in the phase of construction and in the phase of operation and maintenance. The output of the EIA process has got the form of the final statement of the EIA authority. This statement focuses on setting the preconditions for following designing, construction, in-use setting and operation and maintenance of the transport infrastructure. In the countries where the EIA process and permission process in accordance with Building code are not integrated like in Austria (e.g. Slovakia, Czech Republic) the final statement of the EIA authority is binding for the developer and responsible body for issuing the building permission. Concerning ecological aspects, the most emphasis is put on AVOIDANCE and MITIGATION. SEA and EIA processes include as inherent part the public participation process using different methods and tools [3, 4]. The phase of projecting and construction design ends with the process of building permission.

1 In General, Avoidance is the basic choice in SEA and mitigation in the main choice for EIA. In the strategic level (SEA) it is large scale Avoidance (to not touch an N2000) but also in the optimisation of the final alignment (EIA) small scale avoidance is possible and necessary. In the EIA it is then mitigation and compensation.
2.4 Phase 4: Implementation / realisation

The phase of construction is the implementation process in which the approved projects and construction designs are implemented. The construction of the road / railway follows the documentation elaborated in the phase of planning and projecting including the minimising and-or compensating negative effects of the construction and mitigation measures as defined in the permissions. This phase ends with the in-use taking decision. An important part of the realisation phase is the monitoring of the construction work and its effects including the environmental effects and adjustment of the construction in the harmony of the outputs from the monitoring.

2.5 Operation, maintenance and monitoring

This phase includes the operation, maintenance and accompanied monitoring, but an important part of this phase represents proposal and implementation of proper measures in reaction to the monitoring outputs.

The phase of monitoring is an important part of the linear transport infrastructure development focused on identification and assessment of the real effects of the realisation and operation of the transport infrastructure, but what is also important is the monitoring of development dynamics in the surrounding area including the ecosystems changes as well. Special attention should be payed to the satisfaction of the defined demands and fulfilment of all requirements, with the focus on environmental effects, including the wild life and a realisation of mitigative measures. An important dimension of the monitoring is the feedback-based learning. The detailed content of the monitoring of the environmental effects used to be defined in the final binding statement from the environmental impact assessment.

Specific content of the phase of operation, maintenance and monitoring of the updated existing roads and railways

The specifics of the phase of operation, maintenance and monitoring for the update of existing roads and railways are connected with the fact, that there exists a good reference basis for the comparison of the effects of the update in the form of the data to the road or the railway before the update. This allows a very efficient assessment of expected and real effects and addressed proposal of the measures.

| Table 1. An overview of the content of the transport development phases and dominantly used instruments for harmonisation between transport corridors and wild-animals migration corridors |
|---|---|---|
| Phase | Content | Instruments used for harmonization |
| SCOPING | Definition of the demand, framework preconditions, threats. Elaboration of investment intent and decision about investment | Integrative strategic socio-economic development planning (e.g. Agenda 2030), Sectoral planning e.g. transport planning, Land-use planning, ex-ante monitoring, Motivating allowances Special taxes, Public displays, newsletters, press release, news, conferences, Pools, surveys, public hearings, written responses, briefs, |
| PLANNING | Strategic planning, routing of corridor, land use planning, including the corridor into the land use documentation, elaboration of the documentation for the | Integrative strategic socio-economic development planning e.g. regional development plans, Sectoral planning e.g. transport planning, Land-use planning, Landscape planning, Defragmentation plans and „co-existence” maps of grey and green infrastructure, Land use plan, Strategic socio-economic development plans/programs, Landscape plan, landscape ecological plan, Transport general plans, Maps of ecologically |
| Decision | Important territorial elements, concentrers, eco-corridors, buffer zones (e.g. territorial systems of ecological stability), Documentation for the decision about placement of investment (for territorial decision), Permeability evaluation for wider transport corridor surrounding, Biological survey, Migration study, Strategic environmental assessment process, SEA documentation, Final statement of the SEA authority, Environmental assessment methods, Definition of legal obligations and public interests, Decision about placement of investment/territorial decision, Road-less and low traffic areas, Routing/road alignment, Redistribution of the transport performance demand, Innovative transport modes, (permanent/temporal) Decommissioning of the transport infrastructure, road relocations, Vegetation belts, Habitat enhancement, Adaptation of the habitat alongside of the transport line, Regulation of agricultural use of a landscape, Urban sprawl limitation, Translocation, Habitat creation, Ecological compensation, Pools, surveys, public hearings, written responses, briefs, Public meetings, workshops, Mediation, negotiation, arbitration, Multi-actors decision making, voting, referendum |
| --- | --- |
| Detailed planning, elaboration of the documentation for building permission, elaboration of the statements of public interest representatives, building permission | Projecting, Documentation for building permission, Environmental impact assessment process, EIA documentation, Final statement of the EIA authority, Environmental assessment methods, Definition of legal obligations and public interests, Building permission, highway/railway tunnel, landscape bridges, forest paths/roads leading from above over a highway/railway, wildlife passages, modified bridges over infrastructure, tree-top overpasses, highway/railway bridges over forest paths/roads, viaducts and river crossings, Bridges over small streams, Underpasses for large and medium-sized animals, Modified and joint-use underpasses, Underpasses for small animals, Culverts modified for use by terrestrial animals, Passages for fish and other aquatic organisms, Innovative technical solutions (e.g. lowering pollutions and noise, warning sensors based automatic stop), Earthworks: cutting and embankments, Changes in the parameters of the transport infrastructure elements, Mechanical barriers – fences, barriers for amphibians, noise-protection screens (embankments and walls), Vegetation barriers, Other barriers – acoustic, optical, scent, Deterrents - noise, smell, light, shape/picture, Traffic measures - warning signs with sensors, detection systems, slowing belts, adjusting to communication planning/design, Increasing visibility measures - lighting of communication, adjusting to the surroundings of communication, glass stickers, Public meetings, workshops, Mediation, negotiation, arbitration |
| DESIGNING | Designing, Documentation for construction work procurement and for realisation of the construction |
| Projecting, construction design, design of elements, documentation for procurement of the construction and for construction | Projecting, construction design, design of elements, documentation for procurement of the construction and for construction |
| IMPLEMENTATION / REALISATION | Decision about the contractor for the construction, construction, implementation of the measures Documentation of final state of art of the construction (documentation for final building approval) Monitoring of the construction work and effects | Educational activities, Prospective temporal measures for the construction period (bypasses, redirecting, limitations, restrictions and others), Construction work timing (Seasonal limitation of the construction work, limitation of the night work etc.), Construction process monitoring and adjustment, |
|----------------------------|-------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| OPERATION / MAINTENANCE / MONITORING | Decision about in-use setting/final building approval Operation, traffic control and assistance Maintenance, structural and operational maintenance, Monitoring |
| | Maintenance of the transport road elements including the “eco-elements”, Maintenance of the vegetation in the surrounding area Speed limitation, Spatial and/or temporal re-organisation of the transport Ex-post monitoring - Monitoring of the ecosystem including wild animals’ distribution and movement, Monitoring of the negative effects of the transport, Monitoring of the effectiveness of implemented measures, Monitoring program, Telemetry, Visual monitoring (cameras, visual inventarisation, photo traps), Capture/recapture methods, Mortality monitoring, Footprints recording, Animal tracts recording, Mud or powdered marble recording, (ultra) voice detectors, Genetic analyses, Ex-post adjustment measures / Adjustment changes on infrastructure, Mitigation measures reflecting ex-post monitoring outputs, Compensation measures reflecting ex-post monitoring outputs Pools, surveys, public hearings, written responses, briefs, |

**Table 2.** Overview and classification of the tools and measures for harmonisation between transport corridors and wild-animals migration corridors

| Group of tools | Category of tools | Tools |
|----------------|-------------------|-------|
| Ex-ante processes relevant for minimisation of conflicts between transport infrastructure and wild life and tools associated with these processes | Scoping, planning and projecting processes and associated tools | Integrative strategic socio-economic development planning (e.g. Agenda 2030) Sectoral planning e.g. transport planning Land-use planning Landscape planning Projecting and designing Defragmentation plans and „co-existence“ maps of grey and green infrastructure. Land use plan Strategic socio-economic development plans/programs Landscape plan, landscape ecological plan Transport general plans Maps of ecologically important territorial elements, centres, eco-corridors, buffer zones (e.g. territorial systems of ecological stability) Documentation for the decision about placement of investment (for territorial decision) |
| Documentation for building permission | Documentation for construction work procurement and for realisation of the construction |
|--------------------------------------|---------------------------------------------|
| Assessment processes and associated tools | Ex-ante monitoring |
|                                      | Permeability evaluation for wider transport corridor surrounding |
|                                      | Biological survey |
|                                      | Migration study |
|                                      | Environmental impact assessment process |
|                                      | Strategic environmental assessment process |
|                                      | SEA documentation |
|                                      | EIA documentation |
|                                      | Final statement of the EIA/SEA authority |
|                                      | Environmental assessment methods |
| Institutionalisation and decision making process and associated tools | Definition of legal obligations and public interests incl. sectoral demands |
|                                      | Decision about placement of investment/ territorial decision |
|                                      | Building permission |
|                                      | motivating allowances |
|                                      | special taxes |
| educational activities | |
| Processes of construction, maintenance and operation | Prospective temporal measures for the construction period |
|                                      | Bypasses, redirecting, limitations, restrictions and others |
| Construction work timing | Seasonal limitation of the construction work, limitation of the night work etc. |
| Construction process monitoring and adjustment | |
| Maintenance | Maintenance of the transport road elements including the “eco-elements” |
|                                      | Maintenance of the vegetation in the surrounding area |
| Ex post processes relevant for minimisation of conflicts between transport infrastructure and wild life and tools associated with these processes | Ex-post monitoring |
|                                      | Monitoring of the ecosystem including wild animals’ distribution and movement |
|                                      | Monitoring of the negative effects of the transport |
|                                      | Monitoring of the effectiveness of implemented measures |
|                                      | Monitoring program |
|                                      | Telemetry |
|                                      | Visual monitoring (cameras, visual inventarisation, photo traps) |
|                                      | Capture/recapture methods |
|                                      | Mortality monitoring |
|                                      | Footprints recording |
|                                      | Animal tracts recording |
|                                      | Mud or powdered marble recording |
|                                      | (ultra) voice detectors |
|                                      | Genetic analyses |
| Measures aimed at lowering barrier effect – fauna passages | Ex-post adjustment measures | Adjustment changes on infrastructure  
Mitigation measures reflecting ex-post monitoring outputs  
Compensation measures reflecting ex-post monitoring outputs |
|---|---|---|
| Other measures aimed at lowering barrier effect | Overpass | high/way/railway tunnel  
landscape bridges, forest paths/roads leading from above over a highway/railway  
wildlife passages  
modified bridges over infrastructure  
tree-top overpasses |
| | Underpass | high/way/railway bridges over forest paths/roads, viaducts and river crossings  
Bridges over small streams  
Underpasses for large and medium-sized animals  
Modified and joint-use underpasses  
Underpasses for small animals  
Culverts modified for use by terrestrial animals  
Passages for fish and other aquatic organisms |
| | Road-less and low traffic areas |  |
| | Routing/road alignment |  |
| | Redistribution of the transport performance demand |  |
| | Structural innovations – changes | Innovative transport modes  
Innovative technical solutions (e.g. lowering pollutions and noise, warning sensors based automatic stop)  
Earthworks: cutting and embankments  
Changes in the parameters of the transport infrastructure elements  
(permanent/temporal) Decommissioning of the transport infrastructure  
adapting engineering works for use by animals (e.g. water management works)  
Road relocations |
| | Vegetation belts |  |
| | Habitat enhancement |  |
| | Vegetation adjustments |  |
| | Adaptation of the habitat alongside of the transport line |  |
| | Regulation of agricultural use of a landscape |  |
| | Urban sprawl limitation |  |
| Measures aimed at lowering fauna mortality - barriers | Mechanical barriers | fences  
barriers for amphibians  
noise-protection screens (embankments and walls) |
| | Vegetation barriers | acoustic  
optical  
scent |
Other measures aimed at lowering fauna mortality -  

| Deterrents | noise, smell, light, shape/picture, |
|------------|-----------------------------------|
| Translocation |                                        |
| Habitat creation |                                      |
| Ecological compensation |                                  |

Measures aimed at drivers  

| Traffic measures | Traffic/warning signs with sensors  
detection systems  
slowing belts  
adjusting to communication planning/design  
Speed limitation  
Spatial and/or temporal re-organisation of the transport |
| Increasing visibility measures | lighting of communication  
adjusting to the surroundings of communication  
Glass stickers |

Public participation  

| Information spread | Public displays, newsletters, press release, news, conferences  
Collection of information | Pools, surveys, public hearings, written responses, briefs,  
Consultation | Public meetings, workshops,  
Engaging and empowering | Mediation, negotiation, arbitration  
Partnership | Multi-actors decision making, voting, referendum |

3. Conclusions
Planning of the processes developing linear transport infrastructure are of high importance today and will remain to be in the future all over developing and developed world. Besides technical aspects, it is greatly important to consider the ecological impacts of all phases of developing new infrastructure, extending the existing constructions and improving the ecological condition of the existing infrastructure. This paper is a continuation of works within TRANSGREEN and CONNECTGREEN projects focusing on harmonising the interests of the utility providers, users and biodiversity professionals in terms of the spatial planning and its potential to manage and mediate these interests. Even today, this remains as one of the key issues, as there are many solutions as well as financial instruments out there.

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