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Road and Rail Infrastructure IV

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EFFECTIVE AND COORDINATED ROAD INFRASTRUCTURE SAFETY OPERATIONS: COMMON PROCEDURES FOR JOINT OPERATIONS AT ROADS AND TUNNELS

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Abstract

The “Effective and Coordinated Road Infrastructure Safety Operations” (ECORoads) is an on-going project, which is financed by the EU Horizon 2020 Programme. Its general objective is to overcome the barrier emerging from the formal interpretation of the Road Safety and Tunnels Safety Directives that do not allow Road Safety Audits and Inspections (RSA/RSI) to be performed in uniform way along both open roads and tunnels.

The project aims at the definition of an integrated approach for road infrastructure and tunnel safety management, on the basis of the existing legislative framework and the available experience of road and tunnel experts and best practices. This approach comprises the formulation of common rules of procedures for the organization, performance, reporting and evaluation of the joint road safety operations (audit and inspection) at sections consisted of both open roads and tunnels. The approach is tested and validated with pilot safety operations, which are organized at five different test sites Central and Southeast Europe and, at time being, the first two pilot actions were performed, in March and April 2016. This paper presents the ECORoads concept, the developed common approach and the preliminary conclusions from the joint road safety operations performed at Kennedytunnel (Antwerp, Belgium) and at Krrabe tunnel (Tirana – Elbasan highway, Albania), which shall allow the fine-tuning of the procedures for the next set of field tests in Germany (Rennsteig tunnel), Serbia (Belgrade bypass, Strazevica tunnel) and the former Yugoslav Republic of Macedonia (Demir Kapija tunnel) and, at a later stage, the formulation of recommendations for the incorporation of road safety operations into the tunnel safety ones.

Keywords: road safety, tunnel safety, South East Europe, ECORoads project

1 Introduction

RSA operations during the design process or RSI after opening to traffic, according to the prescriptions of the Directive 2008/96/EC (Road Infrastructure Safety Management – RISM) [1], could be beneficial for risk prevention in tunnels. However, the RISM Directive does not apply in road tunnels, which are covered by Directive 2004/54/EC [2] that mainly focuses on safety issues and risk management in case of incidents more general than road accidents (fire, collisions or car breakdown, etc.).

While from the road users’ point of view the road is a unique linear infrastructure generally in open terrain and sometimes in closed environment (tunnels), the strict application of the two Directives leads to a non-uniform approach to the infrastructure safety management outside and inside tunnels. The ECORoads objective is to experiment on the merging of the road and tunnels safety procedures in one integrated approach for joint road safety operations.

2 Methodology

The project comprises Workshops with stakeholders (European tunnel and road managers); exchange of best practices and experiences between tunnel experts and road safety professionals; joint pilot safety operations at five European road sections that feature both open roads and tunnels that have been selected among several candidatures at earlier stage of the project; and, based on their results, formulation of recommendations for the application of the RSA and RSI concepts in tunnel safety operations.

During and after a workshop with stakeholders and a seminar for best practices exchange between road and tunnel experts held in September and November 2015, respectively, the basic principles of the approach for the field tests were set and the aspects regarding the common procedures definition towards the accomplishment of the project's targets were thoroughly discussed. Specifically, issues like the definition of the road sections and tunnel areas to be audited/ inspected; the joint audit/ inspection process; composition, roles and responsibilities of the joint team; tools and methods; coverage of the road users' point of view; reporting, evaluation and monitoring were discussed in detail among the project consortium, stakeholders and experts.

Based on the outcomes of these discussions, available literature and results of previous relevant national and international projects, the common procedures were elaborated [3]. In this aspect, apart from the guidelines of the relevant Directives, several sources and research projects' outputs were identified and have been taken into account, as mentioned in the following chapter that presents the common procedures.

Then, from the experience gained from these field tests, the experts' feedback and the assessment during the 2nd project Workshop with stakeholders in June 2016, the common procedures shall be fine-tuned during the second set of field tests foreseen in the period July – October 2016, providing the basis for the formulation of recommendations for joint road and tunnel safety operations.

3 Common procedures for the joint road safety operations in roads and tunnels

3.1 Planning, organisation, reporting and monitoring the field tests

At each for the ECORoads test sites, a close cooperation and coordination among different partners and stakeholders is a prerequisite for organisational and planning purposes. The involvement of the Infrastructure Managers (IMs) of the test sites should be ensured, and therefore a Facilitator is appointed for each of them to plan the field test, organise the appropriate meetings and site visits, and cooperate and obtain from the IMs the necessary data for the scope of RSA/RSI. Following the definition of the Common Procedures, the Facilitators and the hosts-IMs set out the dates, the programme, the composition of the visiting team (called RSA/RSI Group) and RSA/RSI experts (called RSA/RSI Core Team).

Two meetings are organised: i) a Briefing Meeting, for presenting to the participants the scope and procedures of ECORoads field tests, for presenting details of the project under RSA/RSI to the RSA/RSI Core Team, for provision of clarifications on issues that emerged from the available data and information, and for gathering information and opinions from external experts and stakeholders; and ii) a Completion Meeting, for the RSA/RSI Core Team to present their preliminary findings to the IM and the RSA/RSI Group. The reporting, feedback and monitoring process comprise:

- The RSA/RSI Report that should contain all the road safety problems and deficiencies that have been identified and commented by the RSA/RSI Core Team and delivered to the IM and the other members of the RSA/RSI Group. It should describe the road safety measures and the experts' recommendations/ advice for solutions to alleviate the encountered problems

and that would reduce risks and accidents' numbers or severity in the short-, medium and long-term. This report is delivered within 2-3 weeks' time.

- The feedbacks from all the involved parties (see section 3.2).
- Report on Common Procedures, regarding the conformity of the procedures followed with the Common Procedures, which is delivered by an "Internal Observer", appointed by the consortium to ensure efficient monitoring of the field tests, and to contribute to the fine-tuning of the procedures and the formulation of recommendations.
- Feedback from the IM on the RSA/RSI Report.
- The Final Report, taking into account the response of the IM.

3.2 Team composition, roles and responsibilities

The ECORoads field tests require a multidisciplinary and multifunctional team that covers both the needs of a) the RSA/RSI simulation and b) monitoring and assessing the common procedures in order to fine-tune the procedures and conclude solid recommendations for joint operations. Each RSA/RSI is performed by a RSA/RSI Core Team, which is an international team of experts that are assigned to jointly and independently (from the IMs) perform an RSA/RSI at a designated field test and report on their findings. The Core Team is consisted of at least three and preferably four (2 road + 2 tunnel) experts, with a road safety expert as Team Coordinator.

This team is part of a wider RSA/RSI Group, which comprises other experts – from the consortium or not – that are involved in the ECORoads procedure. It is a mixed international team of (road/ tunnel) experts and other stakeholders that take part in a field test. It consists of the RSA/RSI Core Team, the "External" observers, the Facilitator and the ECORoads "Internal" observer, and representative of the host organisation/ IMs:

- Infrastructure (Road/ Tunnel) Managers or State/ Regional Road Authority of an ECORoads field test: co-organises and facilitates the RSA/RSI, provides the necessary information and data and responds to the RSA/RSI Report.
- Facilitator: is a local/ national expert and, as previously mentioned, ensures organisation and communication/ cooperation between the IMs and the project.
- "External" Observers: stakeholders with different competences, representing different authorities that can provide information to the RSA/RSI Core Team (particularities of a test site, seasonal conditions, peak months, raining or hard winter days, etc.).
- Other "External Experts" and Stakeholders: other local and national interested parties (incl. road user groups and associations) providing complementary information to the Core Team, notes and remarks to the RSA/RSI Group before and during the Briefing Meeting.
- ECORoads "Internal" Observer: a member of the ECORoads consortium, who takes part in the field test, ensures the conformity of each joint audit/ inspection with the common procedures and reports to the consortium. He/she mostly ensures the effective monitoring of the proper and homogeneous application of the ECORoads Common Procedures and is responsible to present to a Workshop with Stakeholders intermediate comments/ remarks on the two first field tests and formulate any recommendations for the other field tests.

3.3 Common definitions on infrastructure segmentation

The field tests should be performed bi-directionally on adjacent (to the tunnel) open roads, transition areas and tunnel interior, presented in Figure 1. The length of the open road in each field test is defined, taking into account the influence of the tunnel before the transition area of the tunnel and it is defined based on the local conditions and particularities, after receiving information from the IMs and local experts, and taking into account the distance of warning of road users about the existence/ approach to the tunnel (vertical signage and road marking) and the presence of adjacent interchanges, entry/ exit ramps, weaving manoeuvres, etc.

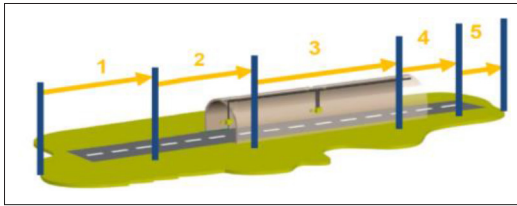


Figure 1 Segmentation of infrastructure for the ECORoads field tests

The transition area between an open road and a tunnel for the scope of ECORoads project, is defined at least as the sum of a) the distance calculated as the distance covered in 10 seconds by a vehicle travelling at the speed limit before the tunnel portal and b) the stopping distance after the tunnel portal, for a vehicle travelling at speed limit, if not identical with design speed. This minimum rule obviously applies on the opposite direction and also – may be slightly modified due to reduced speed within the tunnel – at the exit of the tunnel and on the same direction. The stopping distance may be calculated using one of the equations proposed by PIARC [4], using the initial vehicle speed and other important factors, i.e. the driver reaction time, the longitudinal friction coefficient or the vehicle deceleration rate, etc. Finally, since part of the tunnel infrastructure is considered as part of the transition areas, the tunnel interior section for this exercise is defined as the remaining part of the infrastructure between the transition areas on both sides of a tunnel.

3.4 Data, tools and methods

Generally, the tools and methods to be used in ECORoads exercise (checklists, technical equipment, templates for reporting and evaluation) are those that are implemented according to international and national best practices and recommendations, slightly modified and adjusted to serve the project scope.

3.4.1 Data requirements

The provision of all necessary data is fundamental for the success of the RSA/RSI operations. The required data and documents are explicitly defined for RSI, whilst for RSA vary depending on the project maturity and the RSA level to be carried out, considering that the prepared or on-going (under construction) projects are well advanced in terms of design, as well as that RSA at different road project phases are not always performed by the various countries where the test sites are located. Pictures and video recordings should be also used for preparation purposes, as well as for the preparation of RSI report. The exploitation of such material is encouraged, considering the limited time on site and for ensuring the least exposure of the RSA/RSI Group to traffic during inspections (see section 3.4.3)

3.4.2 Checklists

The use of checklists is recommended, as a mean that ensures a homogeneous approach and assessment of road safety and at the same time the avoidance of failures of noticing all safety problems due to the high expertise and self-confidence of the experts. In that way, the possibility of overlooking some important safety elements due to a more loose approach by the experts, deriving from their expertise on specific aspects, is minimised.

For the scope of the ECORoads exercise, the RSA/RSI checklists proposed by PIARC are adopted as a basis of work, along with the relevant EU Directives' criteria and elements for tunnel safety assessment included in checklists in various countries.

Especially concerning tunnels and transition areas, two checklists were composed, comprising aspects that influence road safety in these sections (e.g. sharp curves of the road alignment near the tunnel, unprotected edges at tunnel portals, use of ordinary road markings

instead of rumble strips), taking into account relevant national RSA/RSI guidelines that include such provisions for RSA/RSI in tunnels [5], [6]. Furthermore, the “Human Factors and Road Tunnel Safety Regarding Users” [7] findings and recommendations are also taken into consideration, as well as RSA training material for safety in tunnels [8], provided that the aspects to be checked in ECORoads should not be all those of the Tunnel Directive, but the main criterion of their inclusion in checklists are oriented to road user’ safety. For transition areas, a combination of aspects from checklists for open roads and the checklists for tunnels is defined and, to avoid duplications, aspects which are profoundly included in transition areas (e.g. portals, drainage, adaptation luminance, etc.) are excluded from checklists for tunnels.

3.4.3 Equipment and safety

Given the project particularities that require mobilisation of people from different European countries, the most advanced equipment and practices usage is encouraged during the field tests, ensuring less time-consuming operations and at the same time less exposure of the RSA/RSI Group to traffic. In this aspect, usage of handheld GPS devices and digital cameras and video cameras with geo-tagging potentials that can be easily georeferenced (complementarily with maps and drawings in appropriate scale, the car odometer and/ or car GPS to cover sections with no or low satellite signals) is encouraged. Other equipment, commonly used in such operations (for measurements of distances, speed, cross falls, lighting conditions etc.) could be used, according to the experts’ requirements and details’ needs.

For open roads and open road parts of transition areas, satellite and aerial photos (ortho-rectified) and ortho-photomaps could be also used for in-house work, with appropriate georeference, preferably in WGS84 Datum – that is used by GPS systems – as well as online mapping tools.

Regarding safety during inspections, both for the road users and for the Inspection/ Group, appropriate measures should be taken, in cooperation with the IMs and Traffic Police. The particularity of carrying out inspections on high speed roads and in tunnels requires more radical safety measures, with closures of traffic lanes), which requires appropriate warning signage (road works and directional signs, flashing lights) at specific distance before the closure occurs.

Especially for tunnel inspections it is preferable to carry out the inspection works during the closure of each tunnel tubes for maintenance. In any case, the days and hours of the field tests should be decided according to the project needs, the traffic conditions and the possibilities for infrastructure closure, and thus with a concern to balance project needs with safety requirements. This enhances the need of dedicating more time in preparatory, in-house work and exploitation of any data and material that would be made available before the field tests (as mentioned in section 3.4.1).

The use of official cars for the transfer to the site and during the inspection would be most preferable, having appropriate warning signage (flashing lights). Members of the RSI Group have to respect the road/ tunnel rules and when outside from the inspection car – where this is permitted – should wear phosphorescent vest and take care not to burden the traffic and road users’ behavior with any unpredicted behaviour or risky activities on site.

4 The ECORoads tests sites

The five test sites of ECORoads, which have been selected among several candidatures through a multi-criteria ranking procedure, are the following:

- Kennedytunnel, Antwerp – Belgium: RSI at a 690m long tunnel under Schelde River, which consists of two unidirectional tubes with three lanes each for car traffic (also 1 tube for train traffic and 1 for pedestrians and cyclists).
- Krraba tunnel, Tirana – Elbasan highway – Albania: RSI at a twin tube tunnel (2.23-2.5km) with two lanes each. Open road sections are motorway on one side of the tunnel (RSI), while construction works are unfinished on the other (RSA).
- BAB A71/ Rennsteig Tunnel – Germany: 19.6km motorway (two traffic lanes per direction) with four consecutive tunnels with total length of 12.6km included. Proposed site for RSI: 10.3km (including the longest tunnel, 7.9km).
- Belgrade bypass Strazevica tunnel, Serbia: RSI at single tube tunnel (745m long) with one lane per direction (bidirectional traffic), along the Belgrade bypass, which is foreseen to be constructed in full motorway profile.
- Demir Kapija tunnel, Corridor X – Former Yugoslav Republic of Macedonia: Single tube tunnel (554m long) with one lane per direction. Open road sections are motorway on one side of the tunnel (RSI), while construction works are unfinished on the other (RSA).

Summarising, apart from RSI to be carried out for existing infrastructures, RSA is to be elaborated for future road and tunnel infrastructures, which are currently under construction or prepared at advanced level.

The joint road safety operations at Kennedy (RSI) and Krrabe (RSA and RSI) have already been performed. Inspections in tunnels were held during night closures in both cases, while inspections during daylight were performed by official cars with appropriate signage, under ordinary traffic conditions and accompanied by the IM personnel. The operations can be considered successful.

5 Conclusions

The ECORoads exercise differentiates from the formal procedures, in order to take advantage of its experimental character, to build on best practices and to provide solid and well documented outputs, and recommendations. The common approach developed and presented in this paper comprises a methodological framework that is based on most recent research and guidelines for RSA/RSI. The proposed tools are deviating somehow from the classic ones used, in order to cover the segmentation of road infrastructure as defined by ECORoads, i.e. open roads, transition areas and tunnel interiors, and checklists for tunnels and transition areas, with focus on road users' safety, have been drafted.

This approach is applied and shall be validated after the first set of ECORoads field tests. Therefore, a fine-tuning of the procedures might be necessary after assessing the success and any failures of the first two field tests. However, from the assessment of the procedures and the feedback of the involved parties in the first two field tests, it emerges that no substantial amendments should be considered, apart from some organisational (logistics) aspects that mostly have to do with the project particularities, such as the mobilisation of experts from different parts of Europe, the unfamiliarity with the scope of the project by other parties, the data requirements for each field test, etc. Anyhow, it was proved in practice, the usefulness of the exercise for the experts to take part in multidisciplinary international teams and especially for road experts to inspect tunnels from the road safety point of view.

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