 DOI: 10.3217/978-3-85125-883-7-04

CURRENT STATUS OF THE WORK IN PIARC'S TECHNICAL COMMITTEE 4.4 TUNNELS

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ABSTRACT

This paper presents the outputs of PIARC's road tunnel committee of the current work cycle 2020-2023. Due to the new PIARC approach in this cycle to have more and earlier outputs, TC4.4 will deliver in total 13 outputs until the end of 2023. Current topics include: Increasing resilience of tunnels, management of urban and heavily trafficked tunnels, impact of new propulsion technologies on tunnel operation and safety, ITS in tunnels, update of the online Road Tunnel Manual, updating and improving of the DG-QRAM Software, organization of the 2nd International Conference on Road Tunnels Operation and Safety and organization of two International Seminars in Low- and Medium-Income Countries (LMIC).

Keywords: Tunnel operation, tunnel safety & resilience, tunnel maintenance, Online Tunnel Manual, transport of dangerous goods, Intelligent Transport Systems (ITS) in tunnels, New Energy Carriers (NEC).

1. INTRODUCTION

The World Road Association PIARC is an international, non-political, non-profit organization, established in 1909. The mission of PIARC is to promote international cooperation on issues related to roads and road transport. Since more than 100 years PIARC continues to foster and facilitate global discussion and knowledge sharing on roads and road transport. The Association now boasts 122 government members worldwide and retains consultative status to the Economic and Social Council of the United Nations. The main objective of PIARC is to facilitate exchange of knowledge on roads and road transport policy and practices within the context of integrated, sustainable transport. PIARC is worldwide acknowledged for the quality of its outputs. The work within PIARC is organized in Technical Committees (TC) which are regularly nominated for a working period of 4 years (so-called work cycles). PIARC's tunnel committee is one of the oldest and one of the largest committees in PIARC. During the past decades the TC Tunnels has produced

- a total of approximately 48 technical reports, covering all matters relating to the operation of road tunnels: geometry, equipment and maintenance, operating, safety and environment,
- numerous articles in PIARC's quarterly magazine Routes/Roads,
- a comprehensive Online Tunnel Manual and
- many more contributions to international events.

Work topics for the TC's are defined in the 4-years Strategic Plan (SP) [1]. The SP for the cycle 2020-2023 includes a new structure of PIARC Technical Committees and task Forces (Figure 1). TC 4.4 Tunnels is part of the Strategic Theme 4 "Resilient Infrastructure".

Strategic Theme 1 Road Administration	Strategic Theme 2 Mobility	Strategic Theme 3 Safety and Sustainability	Strategic Theme 4 Resilient Infrastructure
TECHNICAL COMMITTEES			
TC 1.1 Performance of Transport Administrations	TC 2.1 Mobility in Urban Areas	TC 3.1 Road Safety	TC 4.1 Pavements
TC 1.2 Planning Road Infrastructure and Transport to Economic and Social Development	TC 2.2 Accessibility and Mobility in Rural Areas	TC 3.2 Winter Service	TC 4.2 Bridges
TC 1.3 Finance and Procurement	TC 2.3 Freight	TC 3.3 Asset Management	TC 4.3 Earthworks
TC 1.4 Climate change and resilience of Road Network	TC 2.4 Road Network Operation/ITS	TC 3.4 Environmental Sustainability in Road Infrastructure and Transport	TC 4.4 Tunnels
TC 1.5 Disaster management			
CROSS-CUTTING COMMITEES			
Terminology Committee			
Road Statistics Committee			
RESPONSE TEAM			
PIARC Covid-19 Response Team			
TASK FORCES			
TF 1.1 Well-Prepared Projects	TF 2.1 New mobility and its impact on road infrastructure and Transport	TF 3.1 Road Infrastructure and Transport Security	TF 4.1 Road Design Standards
TF 1.2 HDM-4	TF 2.2 Electric Road Systems		

Figure 1: New PIARC Structure according to 2020-2023 Strategic Plan (SP) [1]

The TC 4.4 Tunnels has currently 150 members (including working group members) representing 37 countries around the world. The work is organized in biannual TC meetings, 4 thematic working groups (WG) and 3 smaller Task Forces (TF) (Figure 2).

Working Groups (WG) cycle 2020-2023	Responsible for Topic (according to the SP)
WG 1 “Sustainable Operations and Maintenance”	4.4.2
WG 2 “Safety and Resilience”	4.4.1
WG 3 “ITS in Tunnels”	4.4.4
WG 4 “New Propulsion Technologies & Ventilation”	4.4.3
Task Force “Knowledge Management / Tunnel Manual”	4.4.5
Task Force “2nd International Conference”	4.4.6
Task Force DG-QRAM	4.4.7

Figure 2: Working Groups and Task Forces in TC4.4 Tunnels

2. CURRENT ACTIVITIES IN THE 2020-2023 PIARC WORK CYCLE

In the following subchapters the planned activities and first results already achieved in the 2020-2023 work cycle are discussed. For detailed information and the free download of already published outputs please refer to the PIARC website (www.piarc.org).

2.1. Measures for increasing resilience of tunnels (topic 4.4.1)

The activities and outputs in relation to the topic “Measures for increasing the resilience of tunnels (4.4.1)” focus on increasing the resilience of a tunnel system, i.e. measures to increase the availability of the tunnel for users and measures to increase the robustness of the tunnel system. A “tunnel system” is defined as the system that consists of e.g. the road (in and nearby

the tunnel), the tunnel construction, the tunnel technical installations, including the control systems / control center from which the tunnel is operated, etc. All these elements work together as a system to assure the safety and availability for the tunnel users, at a certain designated service level (based on requirements set by the tunnel manager). Hence, the integrated performance of all these elements defines the resilience of the tunnel system.

As a first output a comprehensive Literature Review Report "Improving Road Tunnel Resilience, considering Safety and Availability (2021LR01EN)" [2] was produced by WG2. In the report more than 100 literature sources on road tunnel resilience, including more general literature on resilience principles or aspects that could be applied to tunnels, were reviewed and the results were synthesized. Many definitions for "resilience" were found, but the Working Group decided on the following definition in the context of tunnels:

"The ability to prepare and plan for, absorb, recover from, or more successfully adapt to actual or potential negative effects of events or developments affecting the availability of a road tunnel. In this context, an acceptable safety level is a mandatory constraint for the availability of the road tunnel".

The literature review focusses on the following topics:

- General concepts and approaches for resilience management;
- Legislation, standards, strategies and policies;
- Criteria and requirements for resilience, availability and safety as a mandatory constraint;
- Various events and future developments to be resilient for, like weather conditions, climate change and other natural hazards like earthquakes and flooding, traffic incidents and traffic developments, calamities like fire, physical and cyber-security incidents, failure of technical or operational safety measures, including pandemics threatening the availability of the tunnel staff, maintenance and refurbishment works and technical and social developments like SMART mobility and the growing use of new energy carriers for vehicles;
- Possible measures to improve road tunnel resilience for these events;
- Organizational and managerial aspects of resilience improvement.

The report is completed with conclusions and recommendations (for decision makers and for PIARC), an extensive reference list, a glossary and appendices.

The literature review is the first step in the development of a full technical report on road tunnel resilience. The second step is a briefing note including 18 case studies on tunnel resilience collected from 12 countries world-wide. The collection of case studies in the briefing note covers the wide range of resilience topics and aspects mentioned above, thus providing valuable insight in current practices worldwide. Included are cases from Australia, Austria, Belgium, France, Germany, Italy, Japan, The Netherlands, South Africa, South Korea, Spain, Switzerland and The United Kingdom. The briefing note including collection of case studies "Improving Road Tunnel Resilience, considering Safety and Availability (2022R04EN)" [3] has been published in March 2022. The last and final output on the topic of tunnel resilience will be a full technical report which will include a practical road map to manage and improve resilience, "measure sheets" with assessment of effectiveness and cost-effectiveness of various resilience measures with main focus on recovery and recommendations for the target group. The publication of this final output on the resilience topic is foreseen for end of 2023.

2.2. Best practices in management particularly in of urban and heavily trafficked tunnels (topic 4.4.2)

In the past years numerous technical equipment has been installed in road tunnels. The maintenance of this equipment is increasingly complex and has becomes an important issue. This is notably the case in urban tunnels or tunnels with high traffic volume where accessing equipment and conducting road works while the tunnel is open to traffic can be particularly challenging.

The aim of the case study collection report (2022R06EN) [4] was to gather, evaluate and comment on international expertise related to maintenance and traffic management in highly trafficked urban road tunnels. A large number of cases were collected, which were particularly suitable for providing an insight into the implementation of these special requirements for urban road tunnels. It became apparent that it was useful to divide the cases into 3 categories, which pursued similar goals:

- Implementation of the "quick responders" concept with different approaches,
- Measures to organize work and to reduce nuisance to users during the renovation of tunnels,
- New tools for maintenance and operation.

The quick responder's approach is generally considered to be an appropriate measure. However, local requirements must be carefully considered. Specially equipped motorcycles are recommended as suitable responding vehicles. In the second category, various approaches are possible, and these should be tailored as closely as possible to the renovation project in question. Public information campaigns can be just as important as technically sophisticated traffic guidance installations and design adaptations. Probabilistic approaches, e.g. on the basis of the RAMS ISO-standard (reliability, availability, maintainability, safety), can be used to take failure probabilities into account. Such methods are already in use in some cases, but are particularly effective if the methodology can already be deployed during the initial design and construction phase. The final output in this work topic will be a full technical report including recommendations in the fields of traffic, operation maintenance, equipment and refurbishment strategies. The publication is foreseen by end of this year.

2.3. Impact of new propulsion technologies on road tunnel operations and safety (topic 4.4.3)

Alternative propulsion technologies, including battery-electric vehicles, are becoming more prevalent. Whilst such vehicles remain a small overall proportion of the vehicle fleet, the combination of impacts of government policy and technological advances in alternative fuels is expected to accelerate their increase in numbers on the road and in tunnels in coming years. There may also be particular initiatives in certain geographical areas, such as on airport land for example, where higher proportions of alternatively fuelled vehicles are seen sooner than on the open road.

As a result of these changes, the nature of tunnel safety risk (including from fire) is expected to change with time, and detailed consideration of the risk of significant incidents involving such vehicles is required. This should include the evaluation of incident consequences with particular attention paid to fire characteristics and toxic emissions and their impact on tunnel users and on emergency intervention strategies.

The first output of WG4 prepared during this cycle is a case study report "Impact of new propulsion technologies on road tunnel operation and safety (2022R05EN)" [5]. The topic has too few incidents to be able to make statistically relevant statements about the effects of

accidents with vehicles propelled by new propulsion technologies, commonly called new energy carriers (NEC) on the tunnel design and infrastructure. It is also currently not possible to derive specific instructions from experience gained from incidents of such vehicles. Hence, this report collates currently available information on existing or just finished research programs and highlights the most important findings from these projects. The report also presents findings of a "Webinar on New Energy Carriers in Road Tunnels" organized in cooperation with ITA-Cosuf and KPT (Dutch knowledge platform for tunnel safety).

The final output on this topic will be a full technical report to be published at the end of the work cycle (2023).

2.4. Intelligent Transportation Systems in Tunnels (topic 4.4.4)

Regarding Intelligent Transports Systems (ITS), the last few years have seen considerable technological advances in this field. In a road tunnel environment, these systems can have a significant impact on operation and user safety. The objective of this topic is to focus on the impacts of such systems on road tunnel operations and safety. Regarding ITS in tunnels there are a few main issues that needs to be assessed and discussed from a tunnel community perspective:

- Given the very quick development of ITS on open roads, how can service continuity of such systems be guaranteed in the specific context of road tunnels?
- Are there any obstructions for the development of ITS in current tunnels that should be dealt with?
- What changes do we expect in terms of required safety and traffic management systems in a tunnel: what systems could possibly be deleted (under which conditions) and what new systems do we need (under what conditions)?
- What are the tunnel community's expectations with regard to these ITS: safety distance control, lane departure warning systems (LDWS), heavy vehicle guidance systems, vehicle localization and counting systems, identification of hazardous goods vehicles, etc.?
- More generally speaking, how can these ground-breaking systems improve user safety in road tunnels?

The objective of WG3 is to prepare a full technical report answering these questions.

2.5. Update of the Online Road Tunnels Manual (topic 4.4.5)

During the last cycles the TC on Road Tunnel Operations has produced a total of approximately 45 technical reports plus many Routes/Roads-Magazine articles and special issues. In the current work cycle some reports are also already published [2, 3, 4, 5]. The main added value of the Online Tunnel Manual is to incorporate and disseminate this information through an electronic document currently published in a new (2019) version, so as to reach the widest possible audience. The current version of the online Tunnel Manual is available in English and Spanish. The French translation is also finished and the updated pages will be uploaded soon.

The update of the Tunnel Manual will be managed by a Task Force with the support of all Working Groups of TC 4.4. The Tunnel Manual is accessible at https://tunnels.piarc.org/.

2.6. Preparation of the 2nd International Conference on Tunnels (topic 4.4.6)

The previous 1st International conference in Lyon (October 2018) was a very successful event. The 2nd PIARC International Conference on Tunnels will be held from 25 to 28 October 2022 in Granada/ Spain. A Task Force with participation of members of TC4.4 is responsible for the preparation of the technical program in closed collaboration with the Spanish National

Committee of Road Tunnels and other relevant international organizations in the field of Road Tunnels. Important topics which will be addressed are: New challenges of the tunnels with the 2030 objective, Resilience in road tunnels, Management of urban and high traffic road tunnels, ITS systems and their contribution to improved operations, New vehicle propulsion energies and their impact on tunnels, Risk Analysis, Ventilation and Lighting, Emergency Management and Current state of tunnels and adaptation to the regulations. More information about the event, the draft program and registration is available at https://www.piarc-tunnels-spain2022.org/.

2.7. Support for updating and improving of DG-QRAM (topic 4.4.7)

The Dangerous Goods Quantitative Risk Assessment Model, known as "DG-QRAM" is a software tool, which enables its users to perform a specific risk analysis for dangerous goods transport.
Since the release of this software, the DG-QRAM software has been widely used by many European countries to perform risk analysis for dangerous goods transport as required by the European Directive 2004/54/EC on minimum safety requirements for tunnels in the trans-European road network, and to support the choice of a tunnel category according to ADR (dangerous goods regulations).

In the 2016-2019 work cycle the tool was updated to make it compatible with more recent versions of the software that it is based on. Thanks to initial financial contributions provided by 8 funding countries, the updated version of the software tool is available for sale on PIARC website. User training sessions were organized for both expert users and new users. In the current work cycle a further upgrade of the tool, based on feedback of users, is in progress. Preliminary results and more information on the tool were communicated in an International Webinar which was organized by the responsible Task Force in June last year. The presentations and a video are available on PIARC website. It is expected that the upgraded DG-QRAM software will be finalized at the end of the work cycle (2023).

2.8. PIARC Tunnel events

In the current work cycle several events have already been organized by TC4.4:

- International Webinar on „Road Tunnel: Recent Trends, Innovations and Way Forward" streamed from Delhi / India (5 – 6 May 2021),
- Worldwide webinar on the DGQRAM software "A dangerous goods transport risk assessment tool that is being upgraded!", streamed from Lyon / France (23 June 2021),
- Webinar on "New Energy Carriers in Road Tunnels" streamed from Utrecht / The Netherlands (20 – 21 Oct. 2021),
- Technical workshop on road tunnels at 34th Japan Road Conference (4 Nov 2021),
- Technical Session R14 „Increasing Resilience of Tunnels" at the virtual 16th World Winter Service and Road Resilience Congress (9th Feb. 2022),
- World Road Tunnels Seminar, Medellín / Colombia (29th March – 1st April, 2022),
- Several contributions to conferences where PIARC is co-organizer like 10th International (virtual) Conference 'Tunnel Safety and Ventilation' (1 – 3 Dec. 2020), 3rd International Polish Tunnel Forum (3 – 4 Feb. 2021).

The most important upcoming events are:

- GTFE/PIARC France Conference on Tunnel Asset Management, 2 June 2022, Lyon / France (https://www.gtfe.fr/evenements/la-conference-du-gtfe-piarc-france/),
- 2nd PIARC International Conference on Road Tunnel Operations and Safety, 25 – 28 October 2022 – Granada / Spain (https://www.piarc-tunnels-spain2022.org/),

- PIARC International Seminar ”Advances in Design, Construction and Maintenance of Tunnels”, April 2023 – Delhi & Dehradun / India,
- 27th World Road Congress, 2 – 6 October 2023, Prague / Czech Republic (https://www.wrc2023prague.org/).

3. SUMMARY AND CONCLUSION

Since 1957, date of creation by PIARC of the "Committee on Road Tunnels", the Association has conducted an ongoing activity on all matters relating to the operation of road tunnels: geometry, equipment and maintenance, operating, safety and environment. All outputs are available online (free download) on the PIARC website. In the current work cycle several outputs have already been completed and published on the PIARC website [2 – 5]. A large number of successful events have been organized in the first 2 years of the current work cycle. A number of important tunnel conferences and seminars will follow until the end of the work cycle in 2023.

There will be continuous publications on the PIARC website during the next years because not only full technical reports are published but also intermediate deliverables like a literature review, a collection of case studies or a briefing note. Please visit the PIARC website regularly to stay updated. Anyone interested in contributing to the topics mentioned above is cordially invited to participate in TC 4.4.

4. REFERENCES

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