

LOOKING TO THE FUTURE FROM PIARC'S PERSPECTIVE

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ABSTRACT

This paper presents the new topics which PIARC’s road tunnel committee (TC4.4) will address in the current work cycle 2024-2027. TC4.4 will deliver in total 13 outputs until the end of 2027. Current topics include: Sustainability of Tunnel Operation, Active Modes of Transport (walking, cycling, wheelchair) in Road Tunnels, Digitalization of Road Tunnel Design and Management, Road Tunnel Operation and Safety Issues related to the Usage of New Energy Carriers (NEC) in Road Vehicles, update of the online Road Tunnel Manual, dissemination and possible update of the DG-QRAM Software, organization of the 3rd International Conference on Road Tunnels Operation and Safety and organization of two International Seminars in Low- and Medium-Income Countries (LMIC).

Keywords: Tunnel operation, sustainability, digitalization, tunnel safety, Online Tunnel Manual, transport of dangerous goods, 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 127 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 51 technical reports, covering all matters relating to the operation of road tunnels: geometry, equipment and maintenance, operating, safety, sustainability and resilience,
- 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 2024-2027 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” (similar to last work cycle).

Strategic Theme 1 Road Administration	Strategic Theme 2 Road Mobility	Strategic Theme 3 Safety and Sustainability	Strategic Theme 4 Resilient Infrastructure
Technical Committees			
TC 1.1 Performance of Transport Administrations	TC 2.1 Roads for Accessibility and Mobility in Urban and Peri-urban Areas	TC 3.1 Road Safety	TC 4.1 Pavements
TC 1.2 Contribution of Roads to Economic and Social Development	TC 2.2 Roads for Equity, Accessibility and Mobility in Rural and Interurban Areas	TC 3.2 Winter Service	TC 4.2 Bridges
TC 1.3 Finance and Procurement	TC 2.3 Sustainable Freight	TC 3.3 Asset Management	TC 4.3 Earthworks
TC 1.4 Planning the Resilience of Road Networks - Climate Change and other Hazards	TC 2.4 Road Network Operations and ITS for Sustainability	TC 3.4 Environmental Impacts of Road Infrastructure and Transport	TC 4.4 Tunnels
TC 1.5 Disaster management	TC 2.5 Road infrastructure for Connected and Automated Mobility	TC 3.5 Road infrastructure for road transport decarbonization	TC 4.5 Decarbonization of road Construction and Road Maintenance
Task Forces			
TF 1.1 HDM-4 (postponed)			TF 4.1 Road Design Standards
Cross-cutting committees			
Terminology Committee			
Road Statistics Committee			

Figure 1: New PIARC Structure according to 2024-2027 Strategic Plan (SP) [1]

The TC 4.4 Tunnels has currently 120 members representing 36 countries around the world. The work is organized in biannual TC meetings, 6 thematic working groups (WG) and 1 Task Forces (TF) (Figure 2).

Working Groups (WG) cycle 2024-2027	Responsible for Topic (according to the SP)
WG 1 “Sustainable Operations and Maintenance”	4.4.1
WG 2 “Safety”	4.4.2
WG 3 “Digitalization”	4.4.3
WG 4 “New Propulsion Technologies & Ventilation”	4.4.4
WG5 “Road Tunnel Manual”	4.4.5
WG6 “3 rd International Conference”	4.4.6
Task Force “DG-QRAM”	4.4.7

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

2. TOPICS FOR THE 2024-2027 PIARC WORK CYCLE

In the following subchapters the planned activities in the 2024-2027 work cycle are summarized. For detailed information and the free download of already published TC4.4 outputs please refer to the PIARC website [2].

2.1. Sustainability of Tunnel Operation: new Approaches (topic 4.4.1)

The activities and outputs in relation to the topic “Sustainability of Tunnel Operation: new Approaches” focus on an update of the existing report “First steps to a sustainable approach [3]” with new aspects regarding reduction of energy consumption and use of renewable energy sources for tunnel operation. The topic of sustainability is fast evolving and has a major impact for road tunnel operators. Main questions related to this topic include:

- Energy efficiency and sufficiency (e.g. ventilation, lighting) including self-supplying of energy at tunnels (Figure 3),
- Monitoring of energy consumption,
- Impact of thresholds on energy consumption (e.g. required air quality, lighting level),
- Tools and methods for assessing the sustainability in the planning & design phase (LCA, SD indicators),
- Tools and methods for constraining operation and maintenance cost in both soft and hard aspects; e.g. the former is to set the frequency of daily/ periodical inspection,
- Lifetime related design and optimization of tunnel equipment, operation & maintenance, condition monitoring of tunnel equipment,
- Reduction of operational costs.

As a first output a comprehensive Case Studies Collection with worldwide examples and good practices will be produced in 2025. The publication of the final Full Technical Report is foreseen for 2027.



Figure 3: PV-modules on noise protection tunnels (photo: left: BASt, right: Autobahn GmbH, NL Nordbayern)

2.2. Active Modes of Transport (walking, cycling, wheelchair) in Road Tunnels (topic 4.4.2)

The purpose of this work is to summarize international experiences and good practices regarding pedestrians (including reduced mobility users, e.g. in wheelchairs) and cyclists in road tunnels. The focus will be on tunnels with separate galleries for active mobility users as well as on tunnels with mixed traffic, i.e. pedestrians and cyclists in the same tunnel tube as motorized vehicles. Main topics to be addressed include:

- Roadway sharing issues (coexistence of road traffic (including buses) and cycles, road traffic and cycles and pedestrians) / separate tubes (Figure 4),
- Geometric considerations, necessary cross sections, design aspects (Figure 4),
- Possibilities for retrofitting of existing road tunnels regarding active modes of transport,

- Safety measures to protect road users (like pedestrians, cyclists, reduced mobility users e.g. using wheelchairs) including evacuation issues, smoke ventilation strategies and air quality issues (sanitary ventilation),
- Intermodal aspects (e.g. bus stops in underground facilities),
- Impact on risks for safety and how to take them into account in risk analyses and in the safety documentation.

The existing Report “General principles to improve Accessibility for Persons with Reduced Mobility in Road Tunnels [4]” will be considered. As first outputs two Briefing Notes based on a collection of worldwide examples and good practices for the 2 application cases (one tube or separate tube for non-motorized traffic) will be produced in 2025 und 2026. The publication of the final Full Technical Report is foreseen for 2027.



Figure 4: Road tunnel with mixed traffic (photo: left: Henning Koepke, right: CETU)

2.3. Digitalization of Road Tunnel Design and Management (topic 4.4.3)

The purpose of this work is to investigate the impact of the Digital Transformation on different aspects of road tunnel design, operation, safety and maintenance/inspection. Main topics to be addressed include:

- Digitalization of operation, maintenance and inspection (e.g. IoT sensors for tunnel equipment like e.g. emergency call stations),
- Handling and digitalization of data from new ways of inspecting tunnels, such as the use of drones and robots,
- Project development using BIM methodology and experiences acquired (Figure 5),
- Digital twins for life cycle management, the support of fast and smooth commissioning of a new or renovated tunnel and its equipment or the use of digital twins in the training of tunnel control centre staff, first responders and stakeholder’s management,
- Centralization of documentation and easy access,

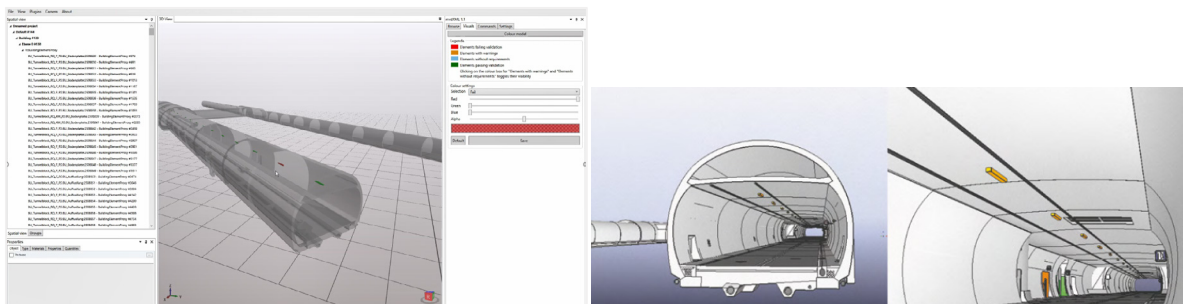


Figure 5: BIM model of a road tunnel (photos: BAST)

A first deliverable on this topic will be a Case Studies report about international experience and technologies already used in 2025 followed by a workshop with stakeholders in 2026. The final output will be a Briefing Note to be published at the end of 2026.

2.4. Road Tunnel Operation and Safety Issues related to the Usage of New Energy Carriers (NEC) in Road Vehicles (topic 4.4.4)

New Energy Carriers (NEC), 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.

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 purpose of this work is to further investigate this fast-emerging topic by collecting and sharing international experiences. There are some relevant open questions after the work done in the 2020-23 work cycle [5] which should be addressed in the 2024-2027 work cycle:

- Incidents with NEC vehicles, collection of data internationally, probability of incidents,
- Intervention / incident management, implications of incidents (e.g. with busses, Figure 6),
- Impact of NEC powered HGV vehicles,
- Impact of NEC vehicles on existing regulation,
- New developments in battery technologies, e-fuels (hydrogen, synthetic fuels) vehicles,
- Pollution and health impact during burning,
- Technologies / solutions to recognize / detect NEC vehicles.

Due to the currently still small number of NEC vehicles on the roads, there is still far too little experience with problems with these vehicles - especially commercial vehicles - in road tunnels. The expected results of the work on this topic will foster the knowledge base for safe operation and incident management of road tunnels.

A first deliverable on this topic will be a Case Studies report about international experience and good practices in 2025. The final output will be a Full Technical Report to be published at the end of the work cycle (2027).



Figure 6: Fire tests and intervention by firefighters (photos: TU Graz / BRAFA project)

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 51 technical reports plus many Routes/Roads-Magazine articles and special issues. The main added value of the Online Tunnel Manual is to incorporate and disseminate this information through an electronic document, so as to reach the widest possible audience.

The current version of the online Tunnel Manual is available in English, Spanish and French. The update of the Tunnel Manual will be managed by a Working Group 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 3rd International Conference on Road Tunnel Operation and Safety (topic 4.4.6)

The previous two International conferences in Lyon, France (October 2018) and Granada, Spain (October 2022) were very successful events. The 3rd PIARC International Conference on Tunnels will be held in October 2026 in Cracow, Poland. A Working Group with participation of members of TC4.4 is responsible for the preparation of the technical program in closed collaboration with the Polish National PIARC Committee and other relevant international organizations in the field of Road Tunnels. More information about the event, and the exact date will be posted soon on PIARC website (www.piarc.org).

2.7. Dissemination and possible update 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.

Numerous road agencies are using the DGQRAM software and/or have set up risk analysis methodologies that are based on this software. They recommend or require that these analyses are included in the safety documentation of operating tunnel bodies or, at least justify some of its content. The improvements make the software more accurate or more user friendly (reducing risk of mistakes) which enhance the quality of the risk analyses. Many improvements have been made in the last work cycle which lead to the publication of the current software version V.10. The software could be ordered at PIARC website.

The following works are planned for the coming 4 years:

- Organize further training sessions with users of the DGQRAM software,
- Collect feedback of users of Version 4.10,
- Implement improvement tasks within phase 3 (continuation of phase 2 from last cycle, depending on funding),
- If relevant (enough improvement tasks implemented within phase 3), organize a Worldwide Webinar to share the advances in the software with users,
- Possible release of a new updated software version (depending on funding).

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.

There will be continuous publications on the PIARC website during the next years because not only Full Technical Reports will be published but also intermediate deliverables like Collection of Case Studies or 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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