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CEDR TRANSNATIONAL ROAD RESEARCH PROGRAMME

Call 2025

Tunnels Management and Renovation

CEDR Transnational Road Research Programme

funded by

(countries to be confirmed)

Description of Research Needs (DoRN)

DRAFT

Draft DoRN has no details of the potential budget or the funding countries, but it has all the necessary technical details.

Publishing DoRN does not constitute a commitment by CEDR or any of its members to launch the corresponding research call.

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1. General Introduction

This Description of Research Needs (DoRN) relates to a Call for Proposals entitled **CEDR Transnational Road Research Programme Call 2025** launched by the Conference of European Directors of Roads (CEDR). CEDR is an organisation which brings together the directors of 29 European road authorities. CEDR provides a platform for cooperation and promotion of improvements to the road system and its infrastructure, as an integral part of a sustainable transport system in Europe. The website ***www.cedr.eu*** contains a full description of its structure and activities.

CEDR recognises the importance of research in the development of sustainable transport and has established Working Groups (WGs) aimed at the analysis of relevant and specific topics of interest from an NRA perspective. Through CEDR Working Groups, CEDR members work together to identify needs for research collaboration and manage research activities.

The Governing Board of CEDR (CEDR GB) has given a mandate to relevant WGs to identify opportunities for transnational road research programmes on an annual basis. CEDR GB also requested that:

- WGs only propose suitable research topics and identifies good research proposals;

- WGs present research proposals, when appropriate, to CEDR GB for decision; CEDR GB will decide what programmes are taken forward;

- All call procedures shall be open and transparent and organisation from all European countries shall be invited to participate, with no advantages given to preferred suppliers or groups of suppliers; and

- The costs of developing and managing the transnational calls shall be supported only by those CEDR members and their partners taking part in the programme.

2. Introduction to Call 2025

The CEDR Transnational Research Road Programme is supported by CEDR to fulfil the common interests of the National Road Authority (NRA) members of CEDR. The participating NRAs in this Call are (to be determined). As in previous collaborative research programmes, the participating members will establish a Programme Executive Board (PEB) made up of experts in the topics to be covered: the PEB will act as a steering committee for the programme. The research budget will be jointly provided by the participating NRAs: the participating NRAs will also nominate the individual member of the PEB. The participating NRAs have designated (to be determined) to act as PEB chair.

CEDR GB has, appointed the CEDR Secretariat to assume the role of Programme Manager (ProgMan) to take over the administration of this Call for Proposals. For this Call, the ProgMan will be Naida Muirhead. The responsibilities of the ProgMan include preparation of the Call for Proposals, financial management of the programme and setting up and managing the contracts with the research providers. These responsibilities will be conducted by the ProgMan in its country under its law and regulations. The terms under which the ProgMan and PEB will operate will be set out in a Collaboration Agreement, signed by senior representatives of each participating NRA.

Applications are invited from suitable qualified contractors in response to this Call for Proposals. In the case of groupings, there are no geographic restrictions on consortia partners provided that any project consortium is led by a legal entity established in a European country.

Individuals and organisations involved in the development or approval of the Call or its management are prohibited from any involvement in proposals. Applications should focus on the sharing of national research, knowledge and experience at all levels as an important prerequisite for achieving the goals of CEDR and its members. This will accelerate the development of faster and durable methods and techniques for road maintenance and management. It is particularly important that the results can be easily implemented by road authorities across Europe, and applicants are encouraged to include case studies and demonstration projects in submissions to contextualise the research and illustrate the benefits of transnational collaboration.

In addition to cooperation with the PEB, selected projects are also expected to work with relevant CEDR Working Groups, activities and other bodies (such as the Executive Board) and include them in the projects' activities (e.g. workshops, etc.). For this call, particular attention may be given, individually or collectively, to WG Collaborative Infrastructure Governance, WG Safe System, and WG Innovation, Research and Skills.

Applications will be evaluated by the PEB in relation to:

- Extent to which the proposal meets the requirement of the DoRN
- Track record of consortium members
- Management of project
- Value for money.

Details of these evaluation criteria and how they will be interpreted and applied by the PEB are presented in the Guide for Applicants (GfA) which accompanies this Call for Proposals.

3. Aim of the Call

The aim of this call is to stimulate the development of broadly applicable outcomes that can be applied to enhance the sustainable management, safety, and operational reliability of tunnels throughout Europe, adopted into the design fabric of future tunnels. The actions proposed should lead to meaningful results, within a two-year timeframe, and offer tangible value to tunnel authorities of all sizes and contexts.

The focus of this call lies on two interconnected topics that address critical challenges faced by many tunnel operators today:

A. Remote Condition Monitoring for Tunnel Asset Management, and

B. Training and Simulation for Tunnel Operations

A. Remote Condition Monitoring for Tunnel Asset Management

The topic focus is on enhancing the way tunnel authorities monitor the **entire condition of tunnels** — including the **civil infrastructure** (i.e. lining, concrete structures, joints, waterproofing, fire-resistant panels, etc.) and the **electromechanical (EM) systems** (i.e. lighting, ventilation, fire-fighting systems, communication/networked devices, etc.) from a maintenance-oriented point of view.

Civil and EM components present different challenges; nevertheless, both are fundamental for safe and sustainable tunnel operation. Some tunnel managers may lack a comprehensive,

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integrated strategy for assessing the condition of these assets in a consistent and data-driven way. This makes it difficult to understand the real-time operational risk to users / customers of asset deficiency or degradation and plan timely interventions, determine long-term investment needs, or clearly define the scope of renewal or renovation projects.

The aim of this topic is to develop a harmonised observation and remote inspection approach, utilise current and emerging technologies including sensors, imaging techniques, modelling (e.g. digital twins), and functional testing.

The objective is to empower and enable tunnel owners and operators to make real-time data-informed, risk-based decisions about their infrastructure — increasing safety, reducing lifecycle costs, and enabling better alignment between monitoring and maintenance, and a proposed risk-oriented maintenance strategy applicable all types of European tunnel.

B. Training and Simulation for Tunnel Operations

The aim of this topic is to strengthen the professional capacity and competence of everyone working in and around tunnels by promoting a common, structured, and coordinated approach to training and simulation across Europe. Tunnel safety and operational performance still depend heavily on human expertise and decision-making. However, there is currently no consistent or harmonised method for preparing professionals for the complex and high-risk tunnel environment.

This topic seeks to support a resilient and well-prepared workforce by improving access to scalable training strategies that complement on-the-job learning, foster knowledge transfer, and build long-term competence for safe and sustainable tunnel operations.

4. Reasons for this Transnational Road Research Programme

The challenges faced by road and tunnel authorities across Europe are increasingly complex, interdependent, with multi or cross-border in consequence. Whether it concerns the ageing of infrastructure, the need for more sustainable asset management, the integration of new technologies, the assurance of operational safety, or the growing impacts of climate change, these issues transcend national borders and require joint and collaborative learning, coordinated innovation, and shared solutions.

This transnational research programme is a response to these shared challenges. It provides a unique opportunity to amalgamate knowledge, align practices, and develop common tools and strategies that can be broadly applied across Europe. By working together, road authorities and research institutes can accelerate innovation, avoid duplication of effort, and ensure that results are both technically robust and practically usable.

There is also a clear efficiency gain: many infrastructure managers face similar issues, but do not have the resources or funding to explore and resolve them in satisfactory depth on their own. A joint research effort allows for deeper investigation, validation across different contexts, and broader implementation of outcomes. This approach supports the development of common standards and guidelines, facilitating interoperability between authorities and a shared or mutual understanding between countries, especially in areas such as tunnel safety, renewal or renovation planning, and operational coordination.

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Furthermore, this programme supports the building of long-term networks and relationships between European road authorities, promoting a culture of open exchange and co-creation. It also enables a more strategic use of limited expertise and resources by identifying sources of excellence and encouraging specialisation and complementarity.

In short, this transnational programme enables:

- Accelerated development and adoption of best practices;
- Smarter, contemporary, more future-proof and better value investment in research and development;
- Practical tools and methodologies that benefit all European road and tunnel managers;
- A stronger and more connected professional community, better equipped to face the transitions ahead.

5. Research Objectives

5.1 Topic A: Remote Condition Monitoring for Tunnel Asset Management

Description of Problem/Description of Research Need

It is common experience in tunnel asset management that a significant amount of data is required before renovation works of a given tunnel can be planned and carried out. It is indeed of utmost importance to avoid incomplete understanding of actual tunnel conditions to properly drive necessary renovation actions and ensure the tunnel remains safe and reliable for its entire lifespan.

Civil and EM components present different challenges; nevertheless, both are fundamental for safe and sustainable tunnel operation. Some tunnel managers may lack a comprehensive, integrated strategy for assessing the condition of these assets in a consistent and data-driven way. This makes it difficult to understand the real-time operational risk to users/customers of asset deficiency or degradation and plan timely interventions, determine long-term investment needs, or clearly define the scope of renovation projects.

Up-to-date information can commonly be obtained by in-person inspections inside tunnels and relevant site investigations at the expense of significant cost and extensive traffic disruption. Moreover, the focus is often placed mainly on the (visible) technical installations within the tunnel. However, defects in civil structures, which are not immediately visible and can be crucial for tunnel safety, are often overlooked and remain undetected.

Remote monitoring represents an efficient tool by which it is possible to detect distress and obtain a complete understanding of tunnel conditions without in-person inspections and consequential impact on traffic. This is the case if all different kind of tunnels—cut-and-cover, drilled or immersed—and their geometric features and specific characteristics are correctly taken into consideration. Additionally, geological contexts (rock mass, soft soils or a combination of both), as well as their positioning (e.g. submerged or above ground) and structural aspects, play a critical role in defining monitoring requirements, as described in the reference ISO16587:2004 standard.

Remote monitoring data collection can be handled in different ways, but the most advanced one is by using a digital model of the tunnel ("digital twin"). By addressing the variability in tunnel types, geological conditions and locations, while incorporating innovative data collection methods, this approach can be effective to significantly enhance asset management practices and optimise the lifecycle management of tunnels, in accordance with ISO55000:2024 standard.

It is necessary to identify and implement remote and real-time monitoring techniques and observation strategies, as well as data management platforms that can handle a very large amount of information. This research should therefore examine and record innovative techniques, technologies and procedures for data collection and management with an eye on effects of climate change. Given the rapid advancement of technology, such as remote sensing, automated monitoring systems and data integration tools, it is essential to incorporate these innovations in practice to improve the efficiency and accuracy of data collection. Leveraging these emerging technologies will ultimately optimise the lifecycle management of tunnel assets and harmonise tunnel management procedures across Europe. The objective is to empower and enable tunnel owners and operators to make real-time data-informed, risk-based decisions about their infrastructure — increasing safety, reducing lifecycle costs, and enabling better alignment between monitoring and maintenance, and a proposed risk-oriented maintenance strategy applicable to all types of European tunnel.

Expected Outputs

- **Inventory of monitoring techniques** for tunnels used in Europe, including those applied in other engineering fields (e.g. railways, mining, marine, etc.) that can be translated into road tunnel management.

- **Inventory of existing data handling platforms** across Europe, including their architecture, capability, effectiveness and applied learning goals.

- **Guidelines for monitoring platform architecture** for both the civil structure and electromechanical systems, adaptable to different types of tunnels (drilled, cut-and-cover, submerged, in mountainous areas, etc.) and equipment, suitable for the latest monitoring techniques and compliant with networked systems security procedures.

- **Proposal for content of technical guidelines for remote inspection and monitoring of tunnels** from an asset management perspective to achieve efficiency and harmonised procedures.

- **Glossary of road tunnel-related technical terms** to assure a common technical basis.

- **Educational webinars (including recordings)**, at least one per above listed expected outputs, for dissemination of knowledge regarding monitoring techniques and the use of monitoring platforms in practice, assessing residual lifetime and safety of road tunnels.

5.2 Topic B: Training and Simulation for Tunnel Operations

Description of Problem/Description of Research Need

Tunnel operation is a highly specialised domain that requires specific expertise, interdisciplinary coordination, and rapid, accurate decision-making under pressure. Yet, there is currently a lack of training programmes tailored to the needs of professionals working in the tunnel business. Unlike other infrastructure domains, no academic curriculum or syllabus specifically prepares individuals for the operational and safety challenges unique to tunnels. This gap creates a strong reliance on on-the-job learning through mentoring, which, while valuable, is not sufficient on its own to guarantee consistency in safety, efficiency, and knowledge transfer across organisations and countries.

Moreover, the tunnel community in Europe is relatively small, and national approaches to training vary significantly in terms of structure, availability, and quality with significant implications for the safety of road users who depend on tunnel infrastructure in their daily journeys. Some countries have access to dedicated training facilities, but these are often developed in isolation, without a coordinated vision or shared standards. The lack of joint training efforts and harmonised simulation exercises limits the ability to learn from each other and reduces the efficiency of emergency preparedness on a European scale.

The research is therefore required to identify available learning-goals and applied techniques, how the sector can develop and promote effective, widely accessible training and simulation tools that strengthen operational readiness. This includes identifying existing tunnels and their training facilities, exploring opportunities for collaboration, and developing common training packages adaptable to different stakeholder groups, including tunnel operators, maintenance contractors, emergency services, and infrastructure managers, and communicate and understanding of what good, hands-on tunnel operation looks like.

The use of digital tools including, VR, immersive learning, serious gaming, and digital twins shall be investigated in applications to support both structured training, continuing professional development and mentored learning, or on-the-job learning. To build long-term resilience in the sector, the research should support the development of a shared learning culture between tunnel authorities, where feedback, simulation, and structured reflection are systematically embedded into daily practices and examples of "good" shared.

Expected Outputs

1. **Insight into the Current Landscape**

Report containing:

- **Overview of European Tunnel Typologies:** A structured database or report detailing tunnel characteristics (construction methods, location, size) relevant to training contexts.

- **Inventory of European Training Facilities and Programmes:** A comprehensive overview (incl. interactive map or searchable platform) of existing tunnel training initiatives, their audiences, and capabilities.
- **Analysis of Existing Learning Goals and Techniques:** A comparative study or synthesis report summarising how learning is currently approached across Europe.
- **Gap Analysis**: A targeted assessment identifying shortages in training infrastructure, underrepresented audiences, and unmet competence areas.

2. Foundations for Harmonisation and Alignment

Report containing:

- **Generic Programme of Requirements for Training Centres:** Practical guidelines that define what infrastructure, expertise and content a tunnel training centre should minimally offer (possibly differentiated by tunnel type and/or user group).
- **Skills Matrix and Baseline Learning Objectives:** A matrix aligning expected competencies with roles, training levels, and learning outcomes, usable for curriculum development, evaluation and development of individual training programmes. This could be potentially used for career development and progress evaluation.
- **Modular Training Concept:** A harmonised and flexible training framework offering tailored modules per stakeholder group, with a strong focus on blended learning and scalability.
  This blueprint provides the pedagogical and structural foundation, with safety at its core, for tunnel-specific training programs across Europe. It is to include:

  - **A modular structure** that allows courses to be assembled flexibly based on user profile (e.g. tunnel operator, traffic controller, civil engineer, emergency responder, contractor, tunnel manager).
  - **Baseline learning objectives and core competencies**, clearly defined for each module and stakeholder type, to ensure consistency across regions and providers.
  - **Integration of e-learning components**, enabling remote access to theoretical content, pre-training preparation, and ongoing refreshers to complement hands-on and scenario-based learning.
  - **Guidance on blended learning approaches**, combining e-learning, classroom instruction, simulation-based training, and on-the-job coaching.
  - **Cross-module connections**, supporting multi-disciplinary training and promoting a shared understanding across different roles in tunnel operations.
  - **Recommendations for certification and evaluation**, to track progress, validate competencies, and promote mutual recognition of training efforts across Europe.

3. Innovation in Training Methods

Report containing:

- **Evaluation of available Digital Tools:** provide an evaluation of the available and applicable tools including but not limited to VR / "immersive learning", serious gaming, or digital twins in tunnel-specific training scenarios with case studies to support.

4. **Implementing the learning culture**

Practical Guidelines for Training Integration: A manual for embedding structured learning in day-to-day tunnel operations, including post-incident debriefing and job-shadowing. This is to include **Learning Culture Implementation Toolkit** as well on fostering organisational learning, including best practices for peer learning, continuous feedback, and reflection.

5. **Long-Term Strategy**

Strategic Roadmap for a European Tunnel Training Network:

A vision document with actionable steps, investment needs, and coordination strategies to build and sustain a European training and simulation network. This roadmap should serve as a **reference document** for policy makers and infrastructure owners, offering a clear and scalable strategy for turning fragmented national efforts into a resilient and cooperative European training ecosystem.

It will:

- **Define the purpose and added value** of a European network, including how it supports harmonised tunnel safety practices, professional development, and cross-border cooperation.
- **Map out key actors and roles**, such as national authorities, training institutes, infrastructure operators, and emergency services, and propose governance models for coordination.
- **Identify priorities and gaps** in current training capacity (e.g. geographic, technical, role-specific), and suggest where new or upgraded facilities would have the greatest impact.
- **Propose phased implementation steps**, from short-term coordination mechanisms (e.g. shared access to existing sites) to long-term investments (e.g. developing new centres or mobile simulators).
- **Include an indicative investment plan** that estimates required funding, potential funding sources (EU, national, public-private), and cost-sharing models.
- **Address issues of accessibility and inclusivity**, ensuring that training opportunities are available to all relevant tunnel professionals across Europe.
- **Incorporate quality assurance and continuous improvement mechanisms** to keep the network adaptive, innovative, and aligned with evolving tunnel technologies and risks.

6. Overview of current and previous activities

A general overview of current and existing relevant research projects undertaken across Europe and other sources of information are outlined in Appendix A. These resources and subsequent reports will provide the starting point for proposals submitted in response to this Call and proposals will be evaluated on this basis. **Applicants must not duplicate existing results or ongoing projects and should inform the tenderer of any similar proposals currently under submission for funding by other publicly funded calls.** Proposals should take full account of the outcomes and state-of-the-art identified in these projects listed below. Failure to take account of available research conclusions or notify the evaluators of similar proposals submitted to other funding schemes will disqualify proposals from this call or lead to termination of an awarded contract as will any form of collusion between competing proposals or any collusion between competing organisations and CEDR members and/or their affiliates.

7. Additional information

The aim of this Transnational Road Research Programme is to provide applied research services for the benefit of national road administrations in Europe. The Call is open to any contractor but lead entities must be established in Europe. Applications using the templates provided must be submitted by the applicant.

The expected duration of this programme is 36 months. The target dates within this programme are as outlined in the Guide for Applicants.

The duration for individual projects can be up to 24 months within the programme timescale and commensurate with the tasks envisaged.

The programme language is English: only proposals submitted exclusively in English are acceptable.

The research budget provided by the participating national road authorities for this research programme is (to be determined).

Please refer to the Guide for Applicants (GfA) for full details of how to submit proposals in response to this Call. Submissions using the templates provided must be made electronically using the CEDR Tenders portal (https://tenders.cedr.eu). Submissions received after the deadline cannot be considered.

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Appendix A: Existing projects and resources

Europe wide

- ISO 16587:2004 Mechanical vibration and shock — Performance parameters for condition monitoring of structures
- ISO 55000:2024 Asset management — Vocabulary, overview and principles
- EN 1997-1:2004 - Eurocode 7: Geotechnical design - Part 1: General rules
- CEDR Call 2021 Remote Condition Monitoring of Physical Road Assets
- AFTES – Association Francaise des tunnels et de l'espace souterrain - Method to assist in asset management for underground structures (2013)

National programmes and resources

- Italian guidelines for road tunnel inspections: https://www.mit.gov.it/nfsmitgov/files/media/normativa/2022-08/ALL%20DM%20247%20Allegato_1_-_LL_GG_gallerie_con_allegati_A-B-C1-C2-D.pdf
- Data needs of tunnel owners: https://www.cob.nl/document/informatiebehoeften-van-de-tunnelbeheerder-update-2024/
- Guidelines to data driven asset management: https://www.cob.nl/document/leertraject-digitale-tunneltweeling/
- Digital learning environment for tunnels: https://www.cob.nl/document/ontwikkelpad-digitale-leeromgeving-tunnels-schema/
- Monitoring material degradation: https://www.cob.nl/document/monitoring-material-degradation-in-tunnels/
- Standards for Highways, Design Manual for Roads and Bridges, Design of Road Tunnels, CD 352
- Standards for Highways, Design Manual for Roads and Bridges, Maintenance of Road Tunnels: CM 430
- Standards for Highways, Design Manual for Roads and Bridges, Inspection and records for road tunnel systems: CS 452
- National Highway Sector Schemes for Quality Management in Highway Works, Management, Operation, Installation and Maintenance of Road Tunnels: NHSS 22
- Monitoring the deformation behavior of an immersed tunnel with distributed optical fiber sensors (DOFS), ISBN: 978-94-6384-412-3, Dissertation Xuehui Zhang, Delft University of Technology, 2023.
- Monitoring Strategy for immersed tunnels, COB October 2022: https://www.cob.nl/document/monitoring-strategy-for-immersed-tunnels-vs1/
- Monitoring of bored tunnels, COB September 2023, version 1 (version 2 will be available at the end of 2025): Verkenning monitoring boortunnels - COB