Conférence Européenne
des Directeurs des Routes

Conference of European
Directors of Roads

CEDR TRANSNATIONAL ROAD RESEARCH PROGRAMME

Call 2021

Climate Change Resilience

CEDR Transnational Road Research Programme

funded by

(countries to be confirmed)

Description of Research Needs (DoRN)

DRAFT

Draft DoRNs have no details of the potential budget or the funding countries, but they have all the necessary technical details.

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

April 2021

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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 2021** launched by the Danish Road Directorate on behalf of 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 identify 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 organisations 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 2021

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 PEB will designate one of its members to act as PEB chair.

CEDR GB has, appointed a Programme Manager (ProgMan) to take over the administration of this Call for Proposals. For this Call, the ProgMan will be the Danish Road Directorate, Denmark. 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. There are no geographic restrictions on contractors, however project consortia must be led by a legal entity established in a European country. Individuals and organisations involved in the development or approval of the Call specification 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 be easily implementable by road authorities across Europe, and applicants are encouraged to include case studies and demonstration projects in submissions so as to contextualise the research and illustrate the benefits of transnational collaboration.

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 undertake research on integrating climate change into decision-making processes and implementing existing research into practice. While the primary focus is on organisations responsible for managing and operating road infrastructure, there are likely to be transferable elements of the research, applicable to wider transport infrastructure, which should be highlighted through the outputs.

The results will help to avoid and minimize the disruptive impacts of increasingly extreme weather events on the existing road infrastructure. This will deliver a safer, resilient and more sustainable European transportation network.

The call will improve European road operators' knowledge, (practical) understanding of, and insight in:

- The impacts and operational risks created by extreme weather and changing weather patterns due to climate change, for the different climate zones in Europe;
- Climate change adaptation measures and approaches to mitigate risks, including:
  - Engineering solutions
  - Holistic and adaptive interventions
  - Nature-based and sustainable solutions - natural assets that can play a role in building resilience; and that may contribute to reducing CO_2
  - A cross asset approach whereby a climatic impact directly affecting one asset class indirectly affects another
  - Area-oriented approaches like planting trees on adjacent land that reduce rainfall run-off
  - Responses that go beyond the boundary of the road itself, involve multiple organizations and new adaptive management and design approaches
  - Methodologies which also take a broader view of benefits including the value of natural assets in building resilience
  - Adaptive operational procedures
  - Adaptation embedded in supply chains
- A resilience approach with attention to both extreme events and gradual changes;

- The understanding of risk, in order to make decisions: whether to mitigate, or to respond differently, e.g. by accepting the network will temporarily close, or to implement different operational procedures;
- Benefits and value of the solutions;
- Climate change resilience in planning, design and construction, asset management and maintenance procedures;
- Dealing with uncertainty when taking measures and making decisions;
- Prioritizing under budget constraints;
- Case studies, business cases and best practices for measures.

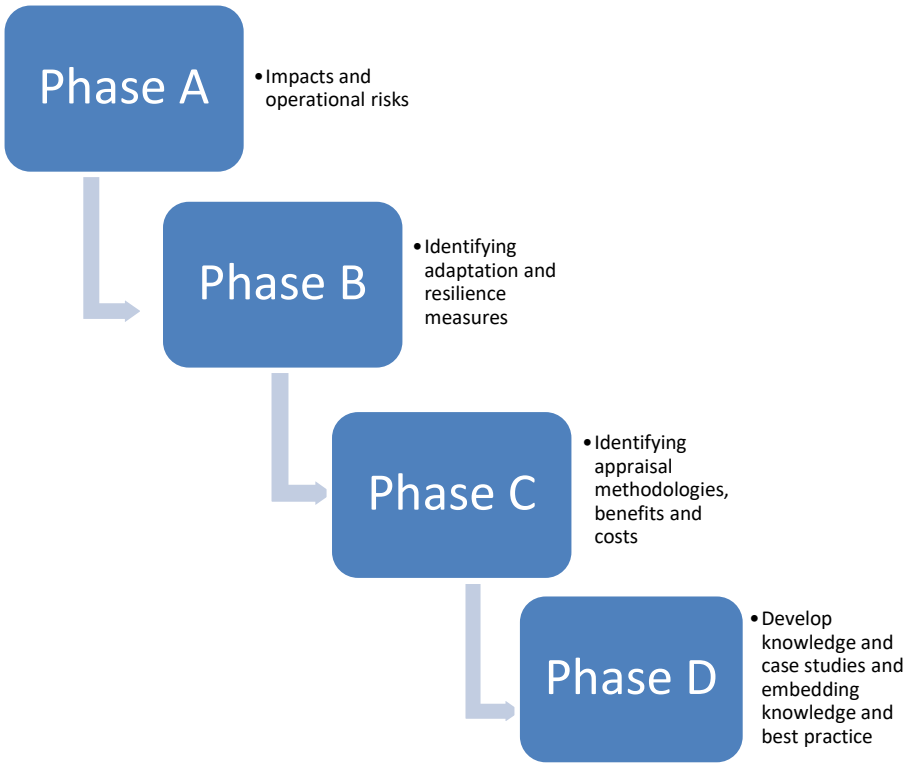
Dissemination leading to implementation is an essential part of the call.

The expected research will build on the outcomes of earlier CEDR calls in relation to climate change: “Road Owners Getting to Grips with Climate Change” (ENR call 2008), “Road Owners Adapting to Climate Change” (CEDR call 2012), and ‘From Desk to Road’ (CEDR call 2015).

The research should also build on available best practices and research sponsored / financed or published by e.g. EU, PIARC, US-FHWA, TRB.

The output will be available on a common (CEDR) knowledge platform and linked to other platforms like Climate-ADAPT (EU).

Because of the linkages and dependencies between different phases of work, the topic of ‘climate change resilience’ has been split into four overlapping phases of work.



4 Reasons for this Transnational Road Research Programme

The UN, the European Union and individual governments all recognize that climate change is a key challenge that must be addressed. Climate change is leading to an increase in the frequency and severity of extreme weather events which can lead to disruptive and catastrophic failure of road infrastructure assets. This causes economic damage and increases safety risks to travellers on the European strategic road network.

Current damage from climate change in the EU is estimated at €12 billion per year[1]. Exposing the present economy to global warming of 3 degrees Celsius would result in an annual welfare loss of at least 175 €billion[2].

Recovering from extreme weather events is costly and disruptive. Therefore, there is a need to avoid these failures where possible and reduce their impacts when they occur.

The road transport system plays a vital role in supporting our societal, economic and environmental systems. Climate change is impacting all these systems, and their interconnectedness amplifies the impact. This interconnectedness also means that the responses to climate change need to be holistic in order to be effective. Understanding the risks requires a broad systems view.

Whilst there is a better understanding of the likelihood of more severe weather, there is less knowledge of the operational impacts of climate change on road assets such as structures, pavements, drainage and earthworks. The response can be limited by constraints such as cost and environmental impact and also by a lack of knowledge about the scale of the threat.

CEDR has recognized the need to address this theme as part of the other challenges to build and maintain reliable, resilient and sustainable networks, across Europe. This recognition, which is widely shared, led to the previous CEDR climate change adaptation calls. The CEDR approach fits with the national policies and the EU approach regarding climate change adaptation.

In accordance with national policies and EU Climate Change Strategy

Lining up with national adaptation policies and the EU strategy will increase the benefits of the CEDR call. In February 2021, the new EU Climate Adaptation Strategy was published. The long-term vision is that in 2050, the EU will be a climate-resilient society, fully adapted to the unavoidable impacts of climate change. Adaptation (including adapted infrastructure) will help to mitigate the effects/reduce damage. In common with this, special attention is given in this CEDR call to nature-based solutions; and a call to adopt a systemic approach is made.

An increase of 30% of the EU budget for climate action for 2021-2027 has been made available. One of the things mentioned is the possibility of inclusion of climate resilience as a criterion for investments. When investing in climate-proof infrastructure, the initial investment

[1] Forging a climate resilient Europe – the new EU Strategy on Adaptation to Climate Change (European Commission)

[2] Economic analysis of selected climate impacts (Joint Research Centre / Europa.eu)

costs may be higher (approx. 3%), but resilience investments have a cost-benefit-ratio of about 1:4[3]

Follow up of previous calls and knowledge development

Following the previous CEDR calls, substantial knowledge has been gained and useful tools have been developed under the CEDR flag (available on the CEDR website),[4] next to information available in Europe (European Climate Adaptation Platform[5]) and worldwide, such as on the United States (US) Department of Transport Federal Highway Administration (FHWA) website[6] and PIARC[7].

The output of this call is focused on the implementation/mainstreaming of tools and results. Projects resulting from this call will provide insight on how to use and implement former results, how to actually "get climate change adaptation done" and, as a result, can lead to the improvement of presently available tools and guidelines.

5 Research Objectives

5.1 Topic: Climate Change Resilience

As a result of the linkages and dependencies between different phases of work, in this Call there is a single topic which has been split into four phases of work:

Phase A: Impacts and operational risks

Phase B: Adaptation and resilience measures

Phase C: Appraisal methodologies, benefits and costs

Phase D: Developing knowledge and case studies and embedding knowledge and best practice / Training module

Phases A, B and C focus on collating and interpreting existing research and developing new knowledge where there are gaps. Phase D is focused on mainstreaming and implementing this knowledge.

While phases can be arranged in a broadly sequential order, it should be recognized that there will be a high degree of overlap between phases, with some elements depending on outputs from earlier preceding phases and other elements able to be progressed independently of earlier work.

[3] Adapt now: a global call for leadership on climate resilience - Global Centre on Adaptation (gca.org)

[4] Publications (CEDR public website)

[5] Home — Climate-ADAPT (europa.eu)

[6] Resilience - Sustainability - Environment - FHWA (dot.gov)

[7] Work Topic Resilient Infrastructure (piarc.org)

5.2 Phase A: Impacts and Operational Risks

Description of Problem/Description of Research Need

Climate change is projected to have significant effects across Europe, including to the road system. The degree of change is dependent on future greenhouse gas emissions. However, the IPCC's 5th Assessment Report shows projections for Europe, including: increases in temperature throughout the continent, with a marked increase in high temperature extremes; and increasing precipitation in Northern Europe and decreasing precipitation in Southern Europe, though heavy precipitation events are expected to increase across much of the continent. Global sea levels will also rise, with variations in the risk of storm surges across Europe's coastlines[8].

These climatic changes are likely to present a number of impacts to road infrastructure. For example, components of bridges may be subject to thermal expansion, geohazards such as landslides may block roads and impact safety, and increased incidence of flooding may inundate or damage roads.

While impacts may directly affect a road asset, many impacts may occur to a combination of assets. For example, an inability to effectively drain roads in a storm event could have knock-on effects on pavements and structures that may be immediate (inundation of the road, reduced skid resistance, damage to road gantries) or delayed (subsequent freeze-thaw action on pavement, delayed or cumulative damage to earthworks). Similarly, pathways for impacts may not sit solely within the influence of one organization and external dependencies may exist (for example, management of adjacent land to the road may positively or negatively affect the risk of flooding to the road). Understanding the pathways across which impacts occur will be beneficial in formulating more effective adaptive responses.

In addition, much of the discussion on climate effects is around the impact of extreme events, for example heatwaves or storm surges are often treated as singular events. However, there may be incremental and cumulative risks to assets that may take place over extended periods of time. For example, damage may occur as a result of a changing water table or salt water intrusion that may have a range of direct, indirect or cumulative effects on highway assets. It is important that adaptation planners understand such dynamic pathways to effectively enable resilience.

Expected Outputs

The research should achieve the outcomes of:

- Collation of existing knowledge on climate risks to roads from across Europe and establishment of new knowledge (e.g. from extrapolation from other sectors or other parts of the world) of pathways across which climate impacts are likely to occur;
- Provision of robust evidence-based approaches to assigning risk to highways asset types in different European contexts that take account of previous research and tools and the latest projected changes in climate.

The research will achieve the following outputs:

- Risk analysis and mapping of pathways of risk to categories of road assets, showing causal relationships and variation in magnitude and geography under differing climate change scenarios;

[8] Climate Change 2014: Impacts, Adaptation and Vulnerability Part B: Regional Aspects (IPCC)

- Listing and categorization of highway asset types and associated geographical / landscape-scale vulnerability to differing climate change scenarios to inform design, maintenance and inspection.

5.3 Phase B: Adaptation and Resilience Measures

Description of Problem/Description of Research Need

As discussed in the first phase, a changing climate is expected to lead to an increase in the frequency and severity of extreme weather events across Europe. However, changes vary according to region, with different rates and degrees of change.

Drafting design standards and maintenance procedures based on uncertain predictions of the rate and degree of climate change can be challenging. Standards of resilience to extreme weather events are mostly determined nationally and based on experience. If an extreme weather event has not occurred yet or does not occur frequently it is not easily taken into account in design standards or maintenance procedures and inspection. Frequently, more immediate impacts of the project, such as costs or direct nuisance for inhabitants, are given preference to adaptation, even though adaptation will probably reduce costs in the long term.

The research will focus on ways of incorporating adaptation into design and construction, maintenance procedures and integrating resilience into operational procedures. Specifically, “viable minimum service levels” should be considered with criteria for acceptability. In this research viable minimum service levels are defined as the acceptance level of a (partly) non-operational road for x amount of time per year due to climatic conditions. This includes consideration of factors including: how long a road might remain closed, how much disruption is acceptable, the impact on travel time; balanced against factors such as cost. Design, maintenance and operational procedures can then be optimized to reduce the time that part of the road is not operational.

In addition, the research will consider barriers to implementing adaptation and resilience measures and propose ways to remove those barriers. These barriers include, but are not limited to, legal barriers, organisational barriers, and difficulties in establishing benefits of adaptation measures (for instance, a lack of proposed indicators to monitor effectiveness of resilience measures).

The research will give an overview of the most effective adaptation measures and seek to fill knowledge gaps, focussing, in particular, on ease of implementation.

Expected outputs

The research should achieve the outcomes of:

- Propose ways to incorporate adaptation into design, construction and maintenance procedures and inspection procedures, and propose new ways of integrating resilience into operational procedures.

The research will result in the following expected outputs:

- An evaluation of existing guidelines (from sources including Climate-ADAPT, CEDR and FHWA on climate adaptation and resilience supported by an assessment of gaps in guidance, resulting in the following:

-Key guidelines for incorporating climate change adaptation and resilience into procurement;
-Key guidelines for incorporating adaptation in concept, design and construction, including guidelines on considering viable future minimum service levels, with criteria for acceptance, and the achievement of wider sustainable development benefits;
-Key guidelines for incorporating climate change adaptation and resilience into maintenance and inspection, including guidelines on considering viable future minimum service levels and the achievement of wider sustainable development benefits;
-Key guidelines for incorporating climate change adaptation and resilience into operational procedures;
-Guidelines on the applicability of emerging innovation in this field;
-Guidelines on the principal supporting evidence needed to integrate and evaluate effective nature based and sustainable solutions.

- Methodology, such as a 'decision tree', on incorporating climate change adaptation and resilience into operational procedures including recommendations on viable future minimum service levels and the achievement of wider sustainable development benefits.

5.4 Phase C: Appraisal Methodologies, Benefits and Costs

Description of Problem/Description of Research Need

There may be circumstances in which climate adaptation measures may increase initial up-front costs or involve increasing frequency of inspection or maintenance. However, this may be contrasted with the potential costs of inaction on climate change. For example, the EU funded COACCH project has anticipated significant annual rises in direct and indirect costs across Europe for the transport sector if no action is taken under both RCP4.5 and RCP8.5 climate scenarios[9].

When making the business case for integrating climate adaptation measures into design, maintenance and inspection regimes a fuller understanding of the whole life costs and benefits of interventions may be beneficial. Cost and benefits should be interpreted in a broader sense than just financial costs here, for instance ecological or social costs should be accounted for too. This may include the reduced future maintenance cost, and may account for wider societal benefits as may be achieved through a nature-based solution that delivers co-benefits, such as carbon reduction, ecological improvements and public health. For example, the United Kingdom government has published a method for developing options and appraising costs and benefits of climate adaptation[10]. However, while broad guidance on approach is emerging in some locations, highway specific approaches to valuation of costs and benefits in different locations is less well understood. In particular, appraising the costs and benefits relative to a baseline will be important.

[9] The Economic Cost of Climate Change in Europe: Synthesis Report on COACCH Interim Results. Policy Brief by the COACCH Project (COACHH). Editors: Paul Watkiss, Jenny Troeltzsch, Katrinona McGlade, Michelle Watkiss

[10] Accounting for the Effects of Climate Change: Supplementary Green Book Guidance (DEFRA)]

Expected Outputs

The research should achieve the outcomes of:

- New research to address knowledge gaps in accounting for whole life costs and benefits of climate resilience in road infrastructure
- Collating evidence on the value of wider benefits that can be achieved through achieving climate resilience
- Substantiate the above using a holistic approach, considering not only financial costs and practicality, but also external sustainability effects such as ecological effects and carbon reduction.

The research will achieve the following outputs:

- An evidence based approach to accounting for climate resilience measures in cost benefit analysis in the context of highways;
- Guidelines (not a tool) on measuring costs and benefits across the whole life of asset types relative to a baseline;
- An approach to recognizing the value and cost impacts of integrating nature based and sustainable solutions to climate change including a list of KPIs to inform future monitoring;
- A separate report in which the above-mentioned approaches are applied to principal adaptation and resilience measures from phase B.

5.5 Phase D: Developing Knowledge and Case Studies and Embedding Knowledge and Best Practice / Training Module

Description of Problem/Description of Research Need

As discussed in Phase A, a changing climate will lead to changes that vary according to region, with differential rates and degrees of change.

The European road network also carries differing levels of traffic, traverses many terrains and is subject to a wide variation in climatic conditions. Climate change therefore has differing impacts on European transportation networks which poses various challenges which require a range of responses and approaches tailored to the different geographies and climatic conditions.

It also provides the opportunity to transfer the experience and knowledge from where certain conditions exist, and apply it to where such conditions are emerging.

There is therefore a need to gather and share this knowledge in a way that builds on the earlier phases, mainstreams the consideration of climate change resilience and embeds the use of holistic and adaptive interventions in the business activities of national road authorities in an effective and efficient way.

The research will focus on ways of increasing knowledge of and use of holistic and adaptive responses to climate change by national road authorities and their supply chains.

It will take into account, assess and build on the results of relevant, recent and ongoing research, innovation and best practice in this field at the national, European and wider levels (but without repeating work that has already been done).

It will consider and use the knowledge and experience of relevant stakeholders including road authorities, city authorities, industry partners and other transport infrastructure owners and operators such as rail.

It will also take into account European geographic differences so that the outputs are applicable to all regions and consider both extreme weather events and gradual climate change.

In addition, it will consider the European legislative frameworks and financial instruments that facilitate (or otherwise) the implementation of climate change adaptation and resilience measures.

Taking into account the outputs from earlier phases, the research will include consideration of the asset lifecycle from design, construction, maintenance (including monitoring and inspection), to renovation and renewal. This will inform the prioritisation of climate adaptation and resilience measures.

As part of the dissemination and implementation plan, the research will deliver technical and financial requirements for demonstrator projects that show practical implementation of innovative elements of the outputs of the research and, which subject to the agreement of any 3rd parties involved, could be delivered as part of the implementation of the results of the research.

It should be noted that no discussions with NRAs who may host such a demonstrator project can take place prior to the submission of bids as this will invalidate any submission. However, discussions may take place with interested NRAs once the research is awarded. Therefore, bids should include indicative costs and technical requirements for such projects. It should also be noted that the indicative costs do not form part of the payment schedule of the submission but are to be used to inform a subsequent showcase or demonstrator project.

Expected outputs

The research should achieve the outcomes of:

- Gathering and collating knowledge and best practice on infrastructure adaptations and operational procedures that address climate change impacts and mitigations holistically
- Effectively sharing and embedding knowledge and best practice in road operators and supply chains to increase the deployment and management of sustainable, cross-asset, holistic solutions

The research will result in the following expected outputs:

- Up to 3 demonstration projects, situated in distinct climatic zones, and drawing on key outputs of this DoRN, to be implemented in project host countries;
- Defined core learning objectives and a concise training package, introducing NRAs to the key findings of this DoRN and where and how they can develop further skills and knowledge. This will be in a format that can be placed on the CEDR website.
- Key strategies for assessing and responding to the operational cross-asset risks with holistic and key adaptive interventions tailored to different European situations (for example, legislative frameworks, partnership agreements and available financial instruments and models)

- Case studies that inform the development of business cases
- Case studies, and advice on integration with design standards and specifications.

6 Overview of Current and Previous Activities

There is a wealth of projects and research available in the field of climate change adaptation including that of infrastructure. This includes methodologies for assessing vulnerabilities, risks, costs and benefits, performed stress tests and pilot studies, and possible measures.

There is less information or research on:

- Dealing with uncertainty especially for long term investment and prioritization of measures
- Prioritization through assessment and in the design phase
- Evaluating the efficacy of measures
- Actual implementation of measures
- Integration into working procedures
- Asset management
- Monitoring and possible KPIs
- Cross asset and area oriented approach of adaptation

Therefore, this is the focus of research.

A general overview of current and existing relevant research projects undertaken across Europe and other sources of information is outlined in Appendix A.

These resources and subsequent reports are 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[11] and should inform the tenderer of any similar proposals currently under submission for funding by other publicly funded calls. Proposals should be based on the outcomes and state-of-the-art identified in specific projects listed.

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.

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.

[11] Appendix A

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 administrations 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 (system to be specified by Programme Manager). Submissions received after the deadline cannot be considered.

Appendix A: Existing Projects and Resources

A non-exhaustive list of research relevant to topic areas is presented below. Applicants are reminded not to duplicate existing research.

Title – internet links	Author, organization	Resources for Phases A, B, C or D*	Status
Normative References			
Transportation Research Board Resources | National Academies Transportation planning to the extreme for weather and climate change | Blurbs New | Blurbs | Main (trb.org)	TRB	A, B, C, D	Completed publications and ongoing activity
Climate Change Impacts and Adaptation for Transport Networks and Nodes	United Nations Economic Commission for Europe	A	Completed report
CEDR public website Contains assessment methods, water management guidelines, overviews of existing research and measures, how to deal with climate information in different parts of Europe, etc.	CEDR	A, B, C	Completed publications and ongoing activity
Work Topic Resilient Infrastructure (piarc.org)	PIARC World Road Association	A, B, C, D	Completed publications and ongoing activity
Home — Climate-ADAPT (europa.eu)	The European Climate Adaptation Platform Climate-ADAPT	A, B, C, D	Completed and ongoing reports and database

A new EU Strategy on Adaptation to Climate Change (europa.eu)	EU	A	Competed strategy
Resilience Primer: An Industry Guide to Enhancing Resilience	Transport Research Laboratory / The Resilience Shift	B	Completed guidance
Accounting for the Effects of Climate Change: Supplementary Green Book Guidance	HM Treasury (UK)	C	Completed guidance
FORESEE : Future Proofing Strategies for Resilient Transport Networks against Extreme Events	EU	A, B, C, D	Ongoing research
PANOPTIS Development of a Decision Support System for increasing the Resilience of Transportation Infrastructure based on combined use of terrestrial and airborne sensors and advanced modelling tools	EU	A, C, D	Ongoing research
RESIST, Resilient Transport Infrastructure to Extreme Events	EU	B	Completed and ongoing research
INTACT (On the Impact of Extreme Weather on Critical Infrastructures) /FP7/ CORDIS	EU	A, B, C, D	Completed research
COACCH: CO-designing the Assessment of Climate Change Costs	EU	A, C, D	Ongoing research / tool
SAFEWAY GIS-based infrastructure management system for optimized response to extreme events of terrestrial transport networks- Field testing of the road infrastructure management systems *https://www.safeway-project.eu/en*	EU	A, B	Completed research / tool
Resilience - Sustainability - Environment - FHWA (dot.gov)	FHWA (US)	A, B, C, D	Completed and ongoing research, tools, pilot projects

Nature-based Resilience for Coastal Highways - Ongoing And Current Research - Resilience - Sustainability - Environment - FHWA (dot.gov)	FHWA (US)	A, B, C, D	Completed and ongoing research
C5a, Interreg VB North Sea Region Programme Cloud-to-coast approach for the management of flood risk. Combining the outcomes of seven ongoing Interreg North Sea Region projects,	EU- Interreg	A, B, C, D	Completed case studies
Informative references			
Connecting Nature	EU / Trinity College, Dublin	A, B, C, D	Completed guidance and ongoing research
Delivering Green Infrastructure Along Linear Assets Research project on incorporating Blue Green Infrastructure in Linear Assets. These are referred to as CIRIA I and CIRIA II. Scoping study	CIRIA / TII	A, B, C, D	Ongoing research
Roadmap to the BGI Manual Like the CIRIA Research cited above re Linear Assets, IFLA Europe were involved in research which could inform the preparation of such guidance. A summary and resources are also available on the JNCC website	IFLA Europe, JNCC, BiodivERsA, Natural Resource Wales and EXCEPT	A, B, C, D	Ongoing research
Decision Support Platforms for Climate Change Adaptation: An Overview and Introduction	Palutikof, J.P, Street, R.B, Gardiner, E.P. / Oxford University Environmental Change Institute	B	Completed research
NordicLink	NordicLink	B	Ongoing research and activity

A network of Nordic scientists and stakeholders. Their vision is to secure the linear infrastructure networks against natural hazards and climate change			
Phusicos: Solutions to Risk in Mountain Landscapes EU Horizon 2020 funded to demonstrate 'how nature-based solutions provide robust, sustainable and cost-effective measures for reducing the risk of extreme weather events in rural mountain landscapes'	Phusicos	B, D	Completed publications and ongoing activity
Eklipse: An Impact Evaluation Framework to Support Planning and Evaluation of Nature-based Solutions	Eklipse	C	Completed research
A Framework for Assessing and Implementing Co-benefits of Nature-based Solutions in Urban Areas	Raymond, C.M, Frantzeskaki, N, Kabisch, N, Berry, P, Margaretha, B, Mihai, R.N, Geneletti, D, Calfapietra, C	C	Completed research

Key:

Phase A: Impacts and Operational Risks

Phase B: Adaptation and Resilience Measures

Phase C: Appraisal Methodologies, Benefits and Costs

Phase D: Developing Knowledge and Case Studies and Embedding Knowledge and Best Practice / Training Module