www.piarc.org
2023SP03EN

MANAGING INNOVATION IN TRANSPORT AGENCIES

A PIARC SPECIAL PROJECT

STATEMENTS

The World Road Association (PIARC) is a nonprofit organisation established in 1909 to improve international co-operation and to foster progress in the field of roads and road transport.

This report has been produced by TRL under a contract and supervision of PIARC.

Any opinions, findings, conclusions and recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of their parent organisations or agencies.

This report is available from the internet site of the World Road Association (PIARC): http://www.piarc.org

World Road Association (PIARC)
Arche Sud 5° niveau
92055 La Défense cedex, France

International Standard Book Number: 978-2-84060-820-2

Front cover © TRL

MANAGING INNOVATION IN TRANSPORT AGENCIES

A PIARC SPECIAL PROJECT

AUTHORS/ ACKNOWLEDGEMENTS

Authors / Acknowledgments

The TRL project team who developed or contributed to this report were:

- Kevin McPHERSON – Principal Consultant / Technical Lead
- Robin WORKMAN – Principal Consultant / Institutional Development Advisor
- Robert LEE – Researcher
- Angela FULLER-DAPAAH – Consultant
- Angela LEKEA – Consultant
- Alex WRIGHT – Technical Reviewer
- Alix EDWARDS – Reviewer
- Minal JOSE – Project Manager

The PIARC Project Oversight Team (POT) were:

- Jeffrey ZAHAREWICZ – POT Chair, representing USA / FHWA
- Patrick MALLEJACQ – Secretary General of PIARC
- Jonathan SPEAR – POT Co-Chair, TC 1.1, representing UK
- Christos XENOPHONTOS – Chair of PIARC TC 1.1, representing USA
- José Manuel BLANCO SEGARRA – Secretary of PIARC TC 1.1, (DGC, MITMA, Spain)
- Seye PAPA-DEMBA – Representing Canada
- Valentina GALASSO – Chair of PIARC TC 4.2, representing Italy / Deloitte Consulting Srl

PIARC and TRL would like to express their appreciation to all contributors who provided their input and expertise to participate in the project and share their knowledge and best practice. In particular, we would like to thank the following organisations and individuals:

- Belgium, Vlaanderen: Anne-Séverine POUPELEER, Head of Department of Flemish Brabant at the Agency for Roads and Traffic, and member of Innovation Board of the Agency.
- Chile, Ministry of Transportation and Telecommunications, Smart Cities Unit: Constanza PACHECO GUTIÉRREZ, National Coordinator of Smart Cities Unit; José Antonio VILLA M., University Professor, Manager of Road Studies and Consultant.
- Ethiopian Roads Authority: Alemayehu Ayele ENDALE, Deputy Director General.
- Germany, Die Autobahn: Bernard GYERGYAY, Coordinator for Research, European Affairs and International Cooperation.
- Indian Roads Congress: Sanjay Kumar NIMAL, Secretary General.
- Israel, Netivei: Adi GAMLIEL, VP of Innovation, Strategy & ESG; and Edward YOSILEVSKY, Coordinator, Knowledge Management, and International Relations.
- Korean Expressway Corporation: Jun SIK, General Manager, Organizational Innovation Division.
- Mexican Transportation Institute: Alberto MENDOZA DÍAZ, General Director; Danae Alejandra VILCHIS HERNÁNDEZ, Researcher of Coordination of Economic and Social Studies of Transportation.

- Oklahoma Department of Transportation: Joni SEYMOUR, Chief Innovation Officer, and Tara BROWN, Deputy Chief Innovation Officer.
- Spain, Ministry of Transport, Mobility and Urban Agenda: José Manuel BLANCO SEGARRA, Directorate-General for Roads.
- Uganda National Roads Authority. Mark Henry RUBARENZYA, Head of Research and Development.
- United Kingdom, National Highways: Claire HAMAR, Head of Innovation.
- Utah Department of Transportation: Carlos BRACERAS, Executive Director, and Elizabeth MCMILLAN, Director of Strategic Communications.
- USA Federal Highway Administration: Jeffrey ZAHAREWICZ.

EXECUTIVE SUMMARY

2023SP03EN

MANAGING INNOVATION IN TRANSPORT AGENCIES

Background

The World Road Association (PIARC) has established a Special Projects mechanism to enable it to respond outside the usual four-year Technical Committee cycle to emerging issues and priorities identified by its members. This report responds to the Special Project "Innovation Policies in the Road Sector" Call for Proposals. This PIARC Special Project is about innovation processes at the organisational level for PIARC members. What are the processes or best practices employed by road and transport agencies to encourage and sustain innovation at the organisational level, and to better identify and implement innovations? What lessons on innovation can be learned from other sectors? What recommendations can be established and implemented at the organisational level?

Objectives

PIARC commissioned TRL to undertake a research project to identify the ways in which road and transport agencies encourage and sustain innovation, and to identify any lessons that may be learned from other sectors. Specific objectives included identification of internal and external innovation encouragement strategies, understanding of mechanisms to identify and implement and sustain innovations. The project also sought to develop insights into cultivating a culture of innovation, both internally and with external stakeholders at national and international levels. Furthermore, the project explored the applicability of processes, concepts, and approaches from other sectors to enhance innovation in the road and transport domain.

Literature Reviews

The project conducted literature reviews to identify key concepts, best practice and processes in the field of innovation. A preliminary literature review concentrated on innovation as a generic concept across all organisations. Key literature reviewed included ISO 56000 which defines a generic framework for innovation management regardless of type, sector, or size, whether established, temporary, or starting; the Open Innovation Framework; the Double Diamond Innovation Framework; and the Oslo Manual which provides guidelines for collection, reporting and interpreting data on innovation. The project undertook further literature reviews around aspects of how to promote and sustain a culture of innovation.

Case Studies and Presentations

The project conducted case studies with eleven (11) transport agencies from a range of countries in different regions and income bands in order to understand differences in approaches and attitudes to innovation. These case studies are summarised in the report. Three (3) other agencies gave presentations at Special Project Session 4 on Innovation Policies in the Road Sector at the World Road Congress in Prague in October 2023. Their presentations are also summarised in the report, and examples and lessons from these presentations have been incorporated into the conclusions and recommendations.

EXECUTIVE SUMMARY

Case Study Country and Agencies	Agencies that presented at Special Project Session 4 WRC 2023
Chile: Smart Cities Unit of the Ministry of Transport and Telecommunications	Belgium, Vlaanderen: Agency for Roads and Traffic
Ethiopia: Ethiopian Roads Authority	Spain: Dirección General de Carreteras (DGC), of Ministry of Transport, Mobility and Urban Agenda (MITMA)
Germany: Die Autobahn GmbH	Uganda: Uganda National Roads Authority
India : Indian Roads Congress	
Israel: Netivei Israel	
Mexico : Mexican Institute of Transportation	
Republic of Korea : Korean Expressway Corporation	
United Kingdom: National Highways	
USA : Federal Highway Administration	
USA : Utah Department of Transportation	
USA : Oklahoma Department of Transportation	

Key Drivers for Innovation

The report identified a range of key drivers for innovation in transport agencies. These key drivers arise from within the organisation itself (for example, the need for cost reduction, improved productivity, improved management of risk), and from a complex mix of drivers from customers (for improved quality of infrastructure, better mobility services, improved safety), the national innovation ecosystem (better and cheaper public services, more inclusion, national competitiveness), the technology sector (crowd sourcing, big data, digital twins, artificial intelligence, connected and autonomous vehicles, automated construction, solar roadways, materials development), and international challenges (climate change, the environment, economic development, sustainability).

Culture of Innovation

Most of the case studies, and a lot of academic literature, focus on creating a culture of innovation. This refers to the organisational environment, values, attitudes and practices that encourage the identification, development and implementation of new and creative ideas at all levels. It is about embracing failure, providing resources, recognising and rewarding innovation, celebrating success, leading by example, and promoting collaboration.

The culture of innovation is affected by many of the policies, processes and day-to-day management of an organisation. These include the organisation's structure and human resource management functions. The report described the literature around these concepts, and describes the ways in which the case study agencies have created organisational structures and policies and practices to generate or improve the culture of innovation. It also identified the need for transport agencies to encourage everyday innovation to practical problems ("brilliant basics") from frontline employees.

EXECUTIVE SUMMARY

For many transport agencies, the way in which they interact with their suppliers and with wider industry and stakeholders can create significant opportunities for innovation, as well as a need to understand and where appropriate regulate innovation by others. Given the pace and scale of innovation in the transport sector, innovation in the supply chain and wider stakeholder ecosystem is an area which many transport organisations are actively embracing, through innovative procurement initiatives, competitive challenges, and collaborative long-term roadmaps to deal with more disruptive technologies.

Innovation as a Process

Viewing innovation as a process, rather than as something that 'just happens', has proved a transformative shift in many organisations. This view recognises innovation as a systematic, repeatable set of activities that have defined goals, that can be managed, measured, encouraged, and improved.

The project developed generic process diagrams based on a synthesis of literature and case study processes and practices. It uses these as a framework for discussion of best practice or good practice as identified in this project. The processes include various methods and concepts such as foresighting or horizon scanning to anticipate future trends, conduct of user surveys, use of suggestion boxes, calls for ideas; cost/benefit analysis; risk assessment; technology readiness levels; prioritisation; creation of innovation portfolios; trialling policies and procedures; measurement systems; and dissemination.

Self-Assessment Tools

The report identified a number of self-assessment tools. These can be used to evaluate the capabilities and abilities of organisations, to identify gaps, and to develop action plans to address the gaps. They can also be used as part of a process of monitoring an agency's progress towards a more open approach to innovation.

There are different types of self-assessment tool available. Some focus on the organisation's work culture, and may be opened up to the entire workforce or to a representative sample of the workforce as time and resources permit, to gain feedback from employees. Other tools may focus on the innovation processes within the organisation. Other tools may include surveys of the supply chain or other external stakeholders to get their views on the organisations' innovation performance.

Innovation Management Systems

The report also identified a number of innovation management systems, which are software solutions to support and streamline an organisation's innovation activities. It outlined some of the key functionalities available within such tools, and provided some advice on key features for transport organisations to look out for if considering implementing such tools.

Conclusions and Recommendations

The report identified how innovation is evolving in transport agencies, and gave many examples in the way in which transport agencies innovate and promote a culture of innovation. Viewing innovation as a process focuses thinking on the inputs and outputs, and policies and procedures, around innovation; how the organisation can structure itself to encourage and support innovation; and how it can support innovation through various support processes particularly around human resource management and procurement. Even language around 'failure' is important, and can permeate many different parts of the process, including in HR policies and procedures.

EXECUTIVE SUMMARY

The report also identified some key challenges to innovation. These include funding, regulatory barriers, scaling up of innovative solutions, tracking and measurement of grassroots innovations, resistance to new technology, and a 'too busy to innovate' attitude that is often cited.

Also, in the 2024 – 2027 Cycle, Technical Committee 1.1 will be examining issues and challenges around designing and creating the Transport Agency of the Future. Many of the experiences, findings and recommendations in this report, around creating an environment that encourages and supports collaboration, creative thinking, and the development of new ideas, products, processes and services, will be key to building that future. The recommendations in the report, for road and transport agencies, and for PIARC, are summarised below.

Ref.	Recommendations for Road and Transport Agencies
R1	**Conduct Self-Assessment**. Choose an appropriate self-assessment tool or tools and apply them to help identify a transport organisation's current innovation status, and help articulate its goals and develop action plans for continuous improvement in its innovation process.
R2	**Consider Innovation as a Process** which needs to be managed in the same way as other processes, with inputs, outputs, policies, procedures, and strong leadership and management. Viewing innovation as a process gives clear direction and accountability, a focus on measurable outcomes, and a mindset of continuous improvement. Not all parts of the process need to be implemented at once, a roadmap to develop or improve innovation can be devised and followed over a number of years as the organisation matures.
R3	**Consider a Separate Business Unit or Team to Drive Innovation**. Such a unit can be considered as the owner of the innovation process, it can create and manage an innovation portfolio to help ensure that the business strategy can be achieved through innovation, and provide a clear structure and support to the rest of the organisation to identify, evaluate, develop and deploy innovations. If a full organisational unit is not feasible within available resources, or if an agency is in the early stages of implementation, then a small team or project management office should be considered.
R4	**Consider an Open Innovation Approach**. Citizens, startups, and technology companies are becoming more involved in the innovation process with transport agencies, and the supply chain is being actively encouraged to participate through innovative tendering mechanisms and alternative methods of collaboration. Consider an explicit commitment to open innovation, and all that that entails, to encourage greater innovation both internally and externally.
R5	**Review Funding Mechanisms for Innovation**. There are many different ways in which innovation can be funded. Multiple funding sources may be available in national or regional ecosystems, and the transport agency can look to work with other government agencies to fund innovative activities such as challenge tenders or hackathons to increase private sector participation and to generate additional innovative ideas. Transport agencies should review options or alternative ways of funding innovations, for internal as well as external innovations.

Ref.	Recommendations for Road and Transport Agencies (continued)
R6	**Explore Ways to Integrate Innovation into Human Resource Policies and Procedures.** HR management is fundamental to the culture of innovation in an organisation. Agencies should review their HR policies and procedures to identify opportunities for improvement, for example in staff recruitment, staff evaluation, staff retention, incentives, training programmes specifically on innovation and innovation processes, change management, and mentoring.
R7	**Engage Proactively with National Innovation Ecosystems**, to understand what government funding may be available, investigate and discuss different mechanisms of procurement, avail of innovation training and expertise, build innovation partnerships and networking, and understand how government uses metrics to evaluate effectiveness of their policies.
R8	**Explore Strategies to Better Manage Risk Associated with Innovation**. A structured approach to risk management allows agencies to identify, assess and mitigate potential risks, and use the results of those assessments when creating an innovation portfolio. A more formal process will allow better or earlier identification of challenges, and reduce the likelihood of expensive failures. It may also help improve the culture of innovation in the agency.
R9	**Seek Strategies to Objectively Assess Maturity and Readiness of Innovations**. Technology Readiness Levels (TRLs) provide a systematic way to assess the maturity of a technology, helping agencies understand the risks and potential benefits of adopting or developing a particular innovation. However, TRLs can be subjective, and are often the opinion of the supplier of the technology. Transport agencies should formulate their own TRLs if possible, and apply objective analysis, not simply accept the supplier view. Clearer and more objective assessment of current TRLs should achieve better innovation outcomes.

Ref.	Recommendations for PIARC
R10	**Encourage Road and Transport Agencies to Conduct Self-Assessments**. There are several self-assessment tools that can measure different aspects of an agency's capability to innovate. PIARC should identify, develop, modify and/or promote a range of appropriate self-assessment tool or tools which can be used to help identify a transport agency's organisational culture and processes, to help articulate transport agency goals and develop indicators and action plans for continuous improvement in their innovation process. This will encourage agencies to identify gaps, highlight areas for improvement, and produce a prioritised action plan which should also consider all other recommendations in the report.

Ref.	Recommendations for PIARC (continued)
R11	**Encourage Multilateral Development Banks to Assist with Developing National Innovation Ecosystems where possible, and Encourage Road and Transport Agencies to Participate in their Development.** Supporting development or improvement of national innovation ecosystems would have a knock-on effect on all innovation within that ecosystem, not only for transport but for other sectors.
R12	**Encourage Engagement between Transport Agencies and their National Innovation Agencies**, to identify funding, and improve access to resources, expertise, and networking. In some countries, however, the national innovation ecosystem may not be well-established or mature, and/or transport may not be high on the agenda for government-led innovation. Where possible, PIARC should encourage engagement between the transport agencies and their national innovation agencies.
R13	**Encourage International Collaborations on Innovation**. Where there are already international collaborations for the setup and development of a national innovation ecosystem, PIARC should encourage engagement between that ecosystem and the transport sector in the country.
R14	**Encourage Engagement with Local Transport Authorities**. In many cases, local authorities have additional challenges to innovation over and above those faced by national transport agencies. They are typically under greater financial pressure than their national counterparts, have greater staff constraints, and have fewer opportunities for collaboration with their peers. PIARC should encourage national transport agencies to work with local authority counterparts on various aspects of innovation.
R15	**Further Develop the Innovation Process Model for Transport Organisations**. The process model developed in the report was a useful starting point for discussion of the innovation process. PIARC should develop or refine the process model with additional examples to provide guidance to transport agencies that are considering implementing an innovation process.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

Abbreviation	Definition
AASHTO	American Association of State Highway Transportation Officials
AI	Artificial Intelligence
AID	Accelerated Innovation Deployment program (FHWA)
AR	Augmented Reality
AWV	Vlaanderen (Flanders) Agency for Roads and Traffic (Agentschap Wegen en Verkeer)
BAU	Business as Usual
BIM	Building Information Modelling
CCAM	Connected Cooperative and Automated Mobility
CEDR	Conference of European Directors of Roads
C-ITS	Cooperative Intelligent Transport Systems
DGC	Dirección General de Carreteras (DGC) of MITMA (Spain)
EDC	Every Day Counts program (FHWA)
ERA	Ethiopian Roads Authority
FHWA	Federal Highway Administration (USA)
GDP	Gross Domestic Product
GII	Global Innovation Index
IaaS	Innovation as a Service
ICT	Information and Communication Technologies
IMS	Innovation Management System
IMT	Mexican Institute of Transportation
IOT	Internet of Things
IRC	Indian Roads Congress
ISO	International Standards Organization
KEC	Korean Expressway Corporation
KPI	Key Performance Indicator
MESTI	Ministry of Environment, Science, Technology and Innovation (Ghana)
MITMA	Ministry of Transport, Mobility and Urban Agenda (Spain)
NCHRP	National Cooperative Highway Research Program (USA)
NH	National Highways (UK)
OECD	Organisation for Economic Cooperation and Development
OPSI	Observatory of Public Sector Innovation (Australia)
PDCA	Plan – Do – Check – Act

Abbreviation	Definition
PIARC	World Road Association
PPI	Public Procurement for Innovation
ROI	Return on Investment
SCU	Smart Cities Unit (Ministry of Transport and Telecommunications, Chile)
SDG	Sustainable Development Goal
STIC	State Transportation Council Innovation Excellence Programme (FHWA)
STIP	Science, Technology and Innovation Policy
TIDP	Technology and Innovation Deployment Program (FHWA)
TQM	Total Quality Management
TRB	Transportation Research Board (United States)
TRL	Technology Readiness Level
UAV	Unmanned Aerial Vehicle
UDOT	Utah Department of Transportation
UNRA	Uganda National Roads Authority
VR	Virtual Reality
WIPO	World Intellectual Property Organization
WRC	World Roads Congress (of PIARC)

GLOSSARY OF TERMS

Term	Description
Brilliant basics	"Brilliant basics" is a term used to describe everyday innovations devised by frontline employees who go above and beyond their usual tasks to solve practical problems.
Culture of innovation	A culture of innovation refers to an organisational environment or workplace culture that encourages and supports creative thinking, experimentation, and the development of new ideas, products, processes, or services.
Innovation as a Service	Innovation as a Service (IaaS) is a model that allows organisations to access innovation-related resources and expertise on a subscription basis, rather than investing in in-house innovation capabilities. Examples of Innovation as a Service are: the provision of open innovation platforms that are online communities that connect organisations with external innovation partners; innovation consulting services such as firms providing expertise in innovation strategies, prototyping etc; innovation labs which are physical or digital infrastructure which allow simulation or experimentation; and innovation training and education.
Innovation Management System	Innovation Management Systems are software solutions to support and streamline an organisation's innovation activities.
Innovation portfolio	An innovation portfolio is a tool used by organisations to manage and track their innovation projects and initiatives. It is a structured collection of different innovation efforts, ranging from sustaining, incremental, disruptive and radical improvements. A portfolio will typically include a mix of short-term and long-term projects as well as different types of innovation (such as product or process innovations).
National innovation ecosystem	A national innovation ecosystem encompasses a country's interconnected network of organisations, institutions, policies, and resources that promote innovation. It includes universities, research centers, businesses, government agencies, and funding mechanisms, all working together to facilitate the development and adoption of new technologies, products, and ideas to drive economic growth and competitiveness.
National innovation policy	National innovation policy refers to the set of policies and initiatives implemented by a country's government to foster and support innovation within its borders. Key themes of a national innovation policy include collaboration, funding, support for entrepreneurship, regulatory frameworks (such as intellectual property laws, competition policies, tax incentives), education and training, skills, and international collaboration.

Term	Description
Open innovation	Open innovation is a collaborative approach to innovation that involves actively seeking and incorporating external ideas, technologies, and expertise into an organisation's internal innovation processes.
Technology Readiness Level	A method for estimating the maturity of technologies during the acquisition phase of a program. Originally developed by NASA in the 1970s for space exploration technologies.

1. INTRODUCTION

1.1 BACKGROUND

The World Road Association (PIARC) has established a Special Projects mechanism to enable it to respond outside the usual four-year Technical Committee cycle to emerging issues and priorities identified by its members. This report responds to the Special Project "Innovation Policies in the Road Sector" Call for Proposals.

Many PIARC committees already analyse individual innovations in their particular fields (pavements, road safety, etc.). Innovation was identified by PIARC as one of the four cross-cutting issues in the 2020-2023 work cycle. Technical Committee 1.1 Performance of Transport Administrations held two workshops on the topic of innovation, on "Innovation and the Innovative Organisation" (Seville, Spain, on November 23rd 2021) and "Implementing Innovation – the Critical Step" (Warsaw, Poland, on April 16th 2022). Innovation was also the theme of a break-out session held online at the PIARC Mid-Term Meeting in December 2021.

This Special Project is about innovation processes at the organisational level for PIARC members. What are the processes or best practices employed by road and transport administrations to encourage and sustain innovation at the organisational level? What lessons on innovation can be learned from other sectors? What recommendations can be established and implemented at the organisational level?

PIARC commissioned TRL to undertake a research project to identify the ways in which road and transport organisations encourage and sustain innovation, and to identify any lessons that may be learned from other sectors.

1.2 OBJECTIVES

Specific objectives of the project were to:

- Identify the processes that road and transport organisations implement to encourage innovation in-house and in their ecosystems of partners and stakeholders;
- Identify the processes that road and transport organisations implement to identify relevant innovations and put them into practice;
- Identify the processes that road and transport organisations implement to identify and foresight innovation processes that will be relevant in future;
- Establish how road and transport organisations train and motivate their workforce to handle rapid innovation, which can be disruptive, and to negotiate with partners, which can be challenging;
- Establish how road and transport organisations foster and accelerate innovation, how do they create and sustain a culture of innovation, and capitalise on both internal and external innovations;
- Establish how road and transport organisations liaise with, influence and benefit from other national and international bodies as regards innovation policies, including national innovation agencies, financial support mechanisms, regional calls for projects and the like;
- Establish what process, concepts and approaches for the proposal, filtering and implementation of innovation from other sectors may be applicable to the road and transport sector and to roads and transport organisations.

1.3 SCOPE

Transportation has been on a continuous journey of innovation since the dawn of time. This can be seen in the types of vehicles that have evolved on our roads and in our cities - the horse and cart, the bicycle, the internal combustion engine, the electric car, the hydrogen car, the connected and autonomous vehicle, the e-scooter. The pace of change is accelerating as technologies converge, and as citizens' demands grow, not only for better infrastructure and services but also for often-competing societal demands of improved road safety, mobility, decarbonisation, and sustainability.

But what of the organisations that plan, manage and maintain the road infrastructure and services to support modern road transport? How do they evolve in line with socio-economic drivers, technological change and user demands? What are the drivers for innovation in these organisations? Are the drivers external and led by industry and society? Or are they internal and led by an ever greater need to provide more cost-efficient infrastructure and services? Do roads and transport organisations have explicit strategies and policies to deal with different types of innovation? Do they proactively encourage innovation in their workforce, or do they rely on it "just happening"? Do they measure it? Do they have targets? Do they provide incentives?

This report focuses on how road and transport organisations innovate to meet their evolving needs, how they promote innovation internally, but also how they identify, harness and where necessary regulate innovation externally. It uses case studies from a range of road and transport agencies in different social, economic and cultural environments, across high-, middle- and low-income countries. It reviews models of innovation and provides a summary of key concepts and ideas that can help in improving the way in which road and transport agencies embrace innovation and better meet the challenges that lie ahead.

The word 'innovation' can be used as a noun (e.g. 'an organisation has introduced a new innovation'). However, 'innovation' can also refer to activities or processes resulting in some improvement.

For the purposes of this report, innovation refers to the process of creating and implementing new or significantly improved ideas, products, services, processes, or business models that bring about positive change and deliver value. It involves the application of creativity, knowledge, and resources to address challenges, seize opportunities, and meet evolving needs.

The report covers major transformational innovations as well as the more day-to-day workarounds and practical solutions to operational problems or customer needs.

This report concludes with recommendations for use by policy advisors, decision makers and executives in individual road and transport agencies; and for use by PIARC in helping to promote innovation in its members worldwide.

It is worth noting too that many of the Sustainable Development Goals (SDGs) are related to innovation. Specifically, SDG 9 focuses on building resilient infrastructure, promoting sustainable industrialization, and fostering innovation. Therefore international organisations should be looking to support innovation in its own right to help accelerate improvement of SDGs across wide sectors of society.

1.4 STRUCTURE OF THE REPORT

This report is structured as follows:

- **Chapter 1: Introduction.** This chapter.
- **Chapter 2: Methodology.** Describes the key tasks and activities in this project.
- **Chapter 3: Key Drivers for Innovation**. Identifies major factors that stimulate the process of innovation within transport agencies.
- **Chapter 4: Creating a Culture of Innovation.** Describes what is meant by a culture of innovation, and identifies key ways in which transport agencies promote a culture of innovation.
- **Chapter 5: Review of Concepts and Frameworks.** Identifies key concepts and frameworks from literature which define best practice in innovation or innovation management, and highlights elements of these quoted by the case study agencies.
- **Chapter 6: Innovation as a Process.** Synthesises the literature and case studies to provide a framework for understanding all of ways in which the case study agencies promote innovation.
- **Chapter 7: Self-Assessment Tools.** Describes the types of self-assessment tool identified in the literature, the key features of tools needed by transport agencies, and a potential maturity model for road and transport agencies.
- **Chapter 8: Conclusions and Recommendations.** Key findings, and conclusions reached based on literature reviews, case study responses, and selected presentations from agencies at Special Project Session 4 at the WRC Prague in 2023.
- **Appendix A: References.** Bibliography with all references referred to from this report.
- **Appendix B: Questionnaire.** The list of questions that was sent to case study agencies and completed by relevant personnel in those agencies.
- **Appendix C: Case Studies.** Short summary of the response of each case study agency to the questionnaire.
- **Appendix D: Presentations at WRC 2023.** Short summary of selected presentations from agencies at Special Project Session 4 at the WRC Prague in 2023.
- **Appendix E: Innovation Management Systems.** Describes key features of commercial off-the-shelf innovation management system software products, and how they might benefit a road or transport agency.

1.5 PROJECT OVERSIGHT TEAM (POT)

The Project Oversight Team (POT) provided direction and oversight of the progress of the Project, including participation in regular calls, and review of interim and final products. TRL worked in collaboration with the POT members throughout the project, and was grateful for the contributions and insights of the POT over the duration of the project. Members of POT are listed in the Authors/ Acknowledgements section of this report.

2. METHODOLOGY

The project methodology included four key tasks as shown in Figure 1: Preliminary Literature Review; Identification of Key Concepts, Models and Frameworks; Collection of International Case Studies; and Analysis and Reporting. These are described in the following sections in this chapter.

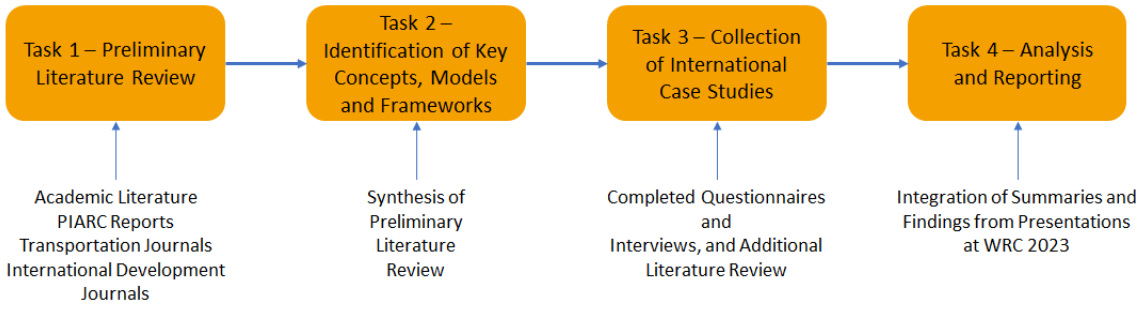

Figure 1. Project Methodology

2.1 PRELIMINARY LITERATURE REVIEW

The aim of the preliminary literature review was to identify key concepts, best practice and processes in innovation. It included review of a range of academic literature, PIARC reports, articles from transportation journals and international development journals.

Desktop research identified literature around how to promote and sustain a culture of innovation. Key themes included the influence of the organisational model on the culture of innovation; the influence of human resource management policies on the culture of innovation; innovation in procurement; and support services including facilitation, communications, training and education. These are described in Chapter 4 of this report.

The review also covered innovation as a generic concept across all organisations (i.e. not only transport organisations). Key literature reviewed included ISO 56000 (International Standards Organization, 2020) which defines a generic framework for innovation management regardless of type, sector, or size, whether established, temporary, or starting; the Open Innovation Framework which is an innovation management concept that has been well researched and promoted in literature; the Double Diamond Innovation Framework (Design Council, 2005) which helps designers and non-designers around the globe tackle some of the most complex, social, economic and environmental problems; and the Oslo Manual (OECD/Eurostat, 2018) which provides guidelines for collection, reporting and interpreting data on innovation and which is key to measuring the value of innovation. These are summarised in Chapter 5 of this report, and are synthesised in Chapter 6 to provide a framework for discussion of innovation as a process in transport agencies.

2.2 IDENTIFICATION OF KEY CONCEPTS, MODELS AND FRAMEWORKS

The preliminary literature review helped identify the key concepts, models and frameworks as described above. These were used to help develop a questionnaire for prospective case study agencies, to gain insight into how those agencies cultivate, embrace and sustain innovation.

The questionnaire was structured as follows:

- Part 1. Introductory information giving the context of the organisation, including name, jurisdiction, primary function, approximate number of employees, annual budget etc.
- Part 2. Overall approach to innovation in the organisation, including the drivers for innovation, existence of explicit policies or strategies to encourage innovation, and the balance between strategic innovations and everyday or incremental innovations.
- Part 3. How a culture of innovation is encouraged within the organisation, giving specific examples of processes and procedures and responsibilities for innovation including, recruitment, evaluation of employees, and motivation.
- Part 4. How a culture of innovation is encouraged in partner organisations or in the supply chain.
- Part 5. How innovations are identified and evaluated in the organisation.
- Part 6. How innovations are implemented in the organisation, including prioritisation and funding of innovations.
- Part 7. How innovations are managed in the organisation, including how the value of innovations is measured, how innovations are institutionalised, and how the organisation promotes or demonstrates the impact of implementing innovations both internally and externally.
- Part 8. Challenges and opportunities for innovation, including barriers to innovation, and what processes, concepts or approaches from other industries may be applicable to roads and transport organisations.

The full questionnaire is given in Appendix B. The questionnaire was sent to a number of case study agencies as described in the next section.

The preliminary literature review also highlighted the importance of self-assessment tools to gauge an organisation's capabilities with regards to innovation. The project therefore undertook additional literature review to identify available self-assessment tools and highlight key features to look out for if choosing a tool. Our review of those is described in Chapter 7.

It was also identified that some agencies use software to manage their innovation process. The project undertook additional literature review to identify key features of commercial off-the-shelf innovation management systems. Appendix E describes the key features of such tools, for consideration by transport agencies.

2.3 CASE STUDIES

The project engaged with eleven (11) transport agencies from a range of countries in different regions and income bands in order to understand differences in approaches and attitudes to innovation.

The case studies took the form of a questionnaire and follow-up interviews where possible. As well as being from different regions and income bands, the agencies included a mix of private, public, and quasi-government organisations, which may also affect their approaches to innovation and the constraints under which they operate. Private sector organisations for example may have greater flexibility in terms of organisational structure, incentives that they can provide, or more choices in their procurement methods; while public organisations may operate within a stricter political and regulatory environment.

It is also important to understand the national context within which each case study organisation operates. The Global Innovation Index (GII) from the World Intellectual Property Organisation (WIPO) was used to identify and select case study countries. All countries chosen either had a GII rank in 2022 within the top three countries in their region, or were among the top three countries in their income group. Transport agencies within those countries were identified from PIARC Project Oversight Team (POT) and consultant contacts. So all case study organisations operate within national ecosystems which are already innovative.

The agencies who provided case studies and presentations fulfil a range of different roles in the transport sector, including policy makers, research and development, operators and managers, which affects their innovation processes.

The purpose of the case studies was to show how transport agencies within those environments innovate, with a view to providing good or best practice examples to other similar agencies. The case study countries and agencies which gave presentations are shown in Figure 2 and are listed in Table 1.

The **Global Innovation Index** (GII) is an annual report published by the WIPO. The GII assesses countries' innovation capabilities. It evaluates factors like human capital, infrastructure, and regulatory environment, ranking nations on their innovation performance. GII helps policymakers and businesses identify strengths, weaknesses, and areas for improvement in innovation ecosystems, guiding investment decisions and international collaboration.

Several agencies also gave presentations at Special Project Session 4 on Innovation Policies in the Road Sector at the World Road Congress (WRC) in Prague in October 2023, and key findings from those presentations have been incorporated into this report. These agencies are also shown in Figure 2 and are listed separately in Table 2.

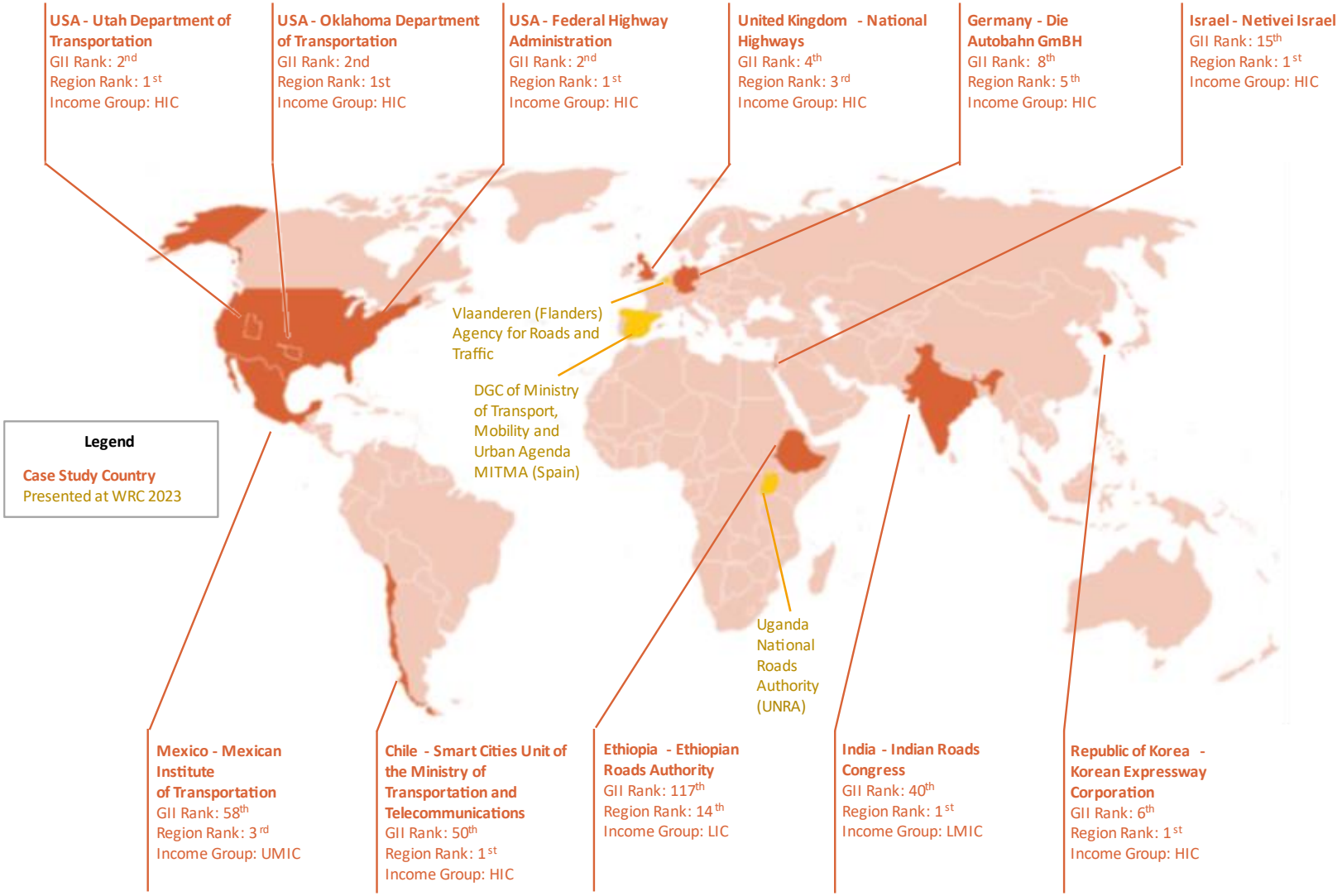

Figure 2. Case Study Countries and Agencies

Table 1. Case Study Countries and Agencies

No.	Case Study Country and Agency	Abbreviation used in this Report
1	Chile: Smart Cities Unit of the Ministry of Transport and Telecommunications	SCU
2	Ethiopia: Ethiopian Roads Authority	ERA
3	Germany: Die Autobahn GmbH	DA
4	India : Indian Roads Congress	IRC
5	Israel: Netivei Israel	NI
6	Mexico : Mexican Institute of Transportation	IMT
7	Republic of Korea : Korean Expressway Corporation	KEC
8	United Kingdom: National Highways	NH
9	USA : Federal Highway Administration	FHWA
10	USA : Utah Department of Transportation	UDOT
11	USA : Oklahoma Department of Transportation	ODOT

Below is a brief description of each agency that provided a case study or presentation as input to this report. Any Gross Domestic Product (GDP) figures are taken from data from the International Monetary Fund (IMF, 2023). Summaries of all case studies are given in Appendix C of this report.

Chile – Smart Cities Unit of the Ministry of Transportation and Telecommunications (SCU)

Chile has a population of 19.2 million, a GDP per capita of 15,000 US$ and is classed as a high-income country. It has been ranked the highest innovative country within South America, with an overall GII of 50. This review found the country to have particularly strong labour productivity growth and strong public institutions. The Ministry has a wide range of responsibilities including road maintenance operation; planning; and regulation. They manage 82,000 km of roads, whose construction ranges from sealed all weather pavements to gravel and unpaved roads. The Smart Cities Unit (SCU) is a multidisciplinary team at a central level within the Ministry that coordinates nationwide technology prospecting projects and initiatives.

Ethiopia - Ethiopian Roads Authority (ERA)

Ethiopia is a landlocked African country with a population of 118 million, and a GDP per capita of 1,200 US$. It is classed as a low-income country. The GII has ranked Ethiopia at 117, making it the 3rd most innovative low-income country. Ethiopia has strong trade and markets relative to its rank, as well as strong knowledge and technology outputs. The Ethiopian Roads Authority (ERA) is responsible for design, construction, and operation of Ethiopia's 30,000 km of national road network. They achieve this with an annual of budget of 1.2 billion US$, and 11,000 employees.

Germany – Die Autobahn (DA)

Die Autobahn is responsible for managing all aspects of the 13,000 km German motorway network, from planning and financing, to construction and maintenance. This is achieved through an annual budget of 7 billion Euros per year. Germany is ranked 8th in the GII, and 5th within the European region. Germany ranks highly in the GII for human capital and research owing to its strong tertiary

education in science, technology, engineering and mathematics, and its research and development expenditure. It has a GDP per capita of 49,000 US$ and an overall population of 83 million.

India – Indian Roads Congress (IRC)

India is a lower-middle income country, with a population of 1.4 billion, and an annual GDP per capita of 2,400 US$. In the GII it is ranked 40, and the most innovative country within central and southern Asia. Its road network has an expansive 6 million route kilometre length, with 34 billion US$ annual development and maintenance budget. This project engaged with the Indian Road Congress, an organisation responsible for developing standards and guidelines, accrediting new materials and techniques. It works closely with the Ministry of Road Transport and Highways (MoRTH). IRC also set up a Highways Research Board which includes three committees, namely: the Committee for Identification, Monitoring and Research Application; the Committee for Accreditation of New Materials/ Techniques/ Technology/ Instruments etc; Committee on Pilot Projects to introduce innovations and support innovative ideas in the road sector.

Israel – Netivei Israel (NI)

Israel has a GII rank of 16. It has the world's highest research and development spending as a percentage of its GDP, as well as the largest amount of venture capital funding and number of international patents. It also boasts the highest percentage of female employees with advanced degrees. It has a population of 8.8 million and an annual GDP per capita of 54,000 US$, and is considered a high income country. Netivei Israel is Israel's National Transport Infrastructure Company, responsible for maintaining and operating their national road network as well as railways, airports and active travel infrastructure. They have 470 employees, and an annual budget of 1.7 billion US$.

Mexico – Mexican Institute of Transportation (IMT)

Mexico is ranked 58th in the GII , with the 3rd highest rank within North America. It is considered an upper middle income country, with a population of 130m and a GDP per capita of 11,000 US$. The Mexican Institute of Transportation (IMT) carries out research and development activities on transport in Mexico, covering a wide range of transport types and aspects, such as: safety, design, planning, construction and maintenance. IMT has a staff of 160, and an annual budget of 10.3 million US$.

Republic of Korea – Korean Expressway Corporation (KEC)

The Republic of Korea is a high income country within south east Asia, with a population of 51.3m and an annual GDP per capita of 32,000 US$. It is ranked 6th in the GII, and is the highest ranked country in the South East Asia, East Asia and Oceania region. It is ranked highest in the world for research employees per population, and second in the world for research and development spending as a percentage of GDP. It is also ranked joint first for patents per GDP. The Korean Expressway Corporation is a private company responsible for highway construction and maintenance of 4,100 km of national roads. It has 9,000 employees and an annual expenditure of 1.4 billion US$.

United Kingdom – National Highways (NH)

This government-owned private company is responsible for the management of motorways and trunk roads in England, comprising some 15,600 route km. It is also partially responsible for road

design and maintenance standards alongside other government bodies. England, as part of UK, is a high income country with a population of 68.2 million and an annual GDP per capita of 45,000 US$. UK's GII rank is 4th in the world, sitting at the 3rd highest ranked European country. Its innovation performance is above expectation for its level of development, with particular strengths in universities and environmental performance. As a case study for the UK, this work engaged with National Highways. It employs 6,000 staff, and has an annual budget of 6 billion US$.

United States - Federal Highway Administration (FHWA)

The role of the Federal Highway Administration in US is to support State and local governments in the design, construction, and maintenance of the nation's highway system and various federally and tribal owned lands. Through financial and technical assistance to State and local governments, the FHWA is responsible for ensuring that America's roads and highways continue to be among the safest and most technologically sound in the world. At the national level, the role of FHWA is primarily to provide transportation stakeholders (state, local municipalities, tribal, etc.) the technical, informational, and fiscal resources necessary to adopt and implement innovation in ways that best support their particular needs and goals. US has a population of around 330 million. The US highway system includes more than 4 million miles of public roads, including over 48,000 miles of Interstate plus 175,000 miles of other routes on what is called the National Highway System (NHS). About 12 % of the non-Interstate NHS roads are locally owned; 88 % are State owned, and less than 1% are Federally owned. US GDP per capita is around 76,000 US$.

United States – Oklahoma Department of Transportation (ODOT)

Oklahoma Department of Transportation (ODOT) is responsible for construction, maintaining, managing and operating highways within the boarders Oklahoma. This includes 19.7 thousand route kilometres of highways among other transport assets, with a total annual budget of 2.4 billion US$. Oklahoma has a population of 4 million. ODOT has 2,300 employees.

United States – Utah Department of Transportation (UDOT)

Utah Department of Transportation (UDOT) within the USA is responsible for planning, designing, building and maintenance of 79,000 route kilometres of roads in Utah. USA is ranked 2nd in the GII ranking. This project engaged with the UDOT as a case study. Utah has a population of 3.3 million. UDOT has 1,700 employees.

2.4 ANALYSIS AND REPORTING

The Analysis and Reporting step consolidated the results of the literature reviews and case studies into a comprehensive and cohesive analysis for the purposes of producing this report.

In addition, Special Project Session 4 Innovation Policies in the Road Sector was held at the World Roads Congress (WRC) in Prague in October 2023. A number of presentations were given at that session, including a presentation on the preliminary findings of this report. Key presentations from that session were used to provide additional examples and recommendations for this report, as shown in Figure 2 and listed in Table 2. We note too that both Die Autobahn and FHWA gave presentations at Special Project Session 4, these agencies have been included above as case studies and are not repeated here.

Table 2. Agencies whose presentations from WRC 2023 have been analysed for this report

No.	Case Study Country and Agency	Abbreviation used in this Report
1	Spain: Ministry of Transport, Mobility and Urban Agenda	DGC/ MITMA
2	Uganda: Uganda National Roads Authority	UNRA
3	Vlaanderen (Flanders): Agency for Roads and Traffic (Agentschap Wegen en Verkeer)	AWV

Below is a brief description of each of agency from Table 2 that provided a presentation for input to this report. Any Gross Domestic Product (GDP) figures are taken from data from the International Monetary Fund (IMF, 2023). Summaries of these presentations are given in Appendix D.

Spain – DGC, Ministry of Transport, Mobility and Urban Agenda (DGC, MITMA)

The Ministry of Transport, Mobility, and Urban Agenda (MITMA) is a Spanish government department responsible for coordinating and overseeing policies and initiatives related to transportation, mobility, and urban development. Its role encompasses the planning, regulation, and development of transportation infrastructure, including roads, railways, ports, and airports, to ensure the efficient movement of people and goods. The Dirección General de Carreteras (DGC) is responsible for the development and monitoring of the planning of the State Highway Network. The state highway network is around 26,400 km in length, and the DGC is in charge of all toll-free roads. Currently state toll motorways are just over 1,400 km in length out of the total of 11,600 km of high-capacity roads. Spain has a GDP per capita of 31,200 US$ and is ranked 29th in the GII.

Uganda - Uganda National Roads Authority (UNRA)

The Uganda National Roads Authority (UNRA) is a key governmental agency in Uganda responsible for the planning, development, maintenance, and management of around 20,000 km of national road network. Established in 2008, UNRA plays a crucial role in enhancing transportation infrastructure across the country, promoting economic development, and improving accessibility for both urban and rural areas. Uganda has an annual GDP per capita of 1,100 US$. The Head of Research and Development in UNRA presented at the WRC in October 2023 on UNRA Research, Development and Innovation Policy, and the key elements of that presentation have been included here.

Vlaanderen (Flanders) - Agency for Roads and Traffic (AWV)

Vlaanderen is a northern region of Belgium, where the predominant language spoken is Dutch. The GDP per capita of the Vlaanderen region is approximately 40 thousand US$. The region's transport network includes 118,000 km of roads, of which 1,700 km are motorways, which are managed by the Flemish government.

3. KEY DRIVERS FOR INNOVATION

3.1 OVERVIEW

All organisations innovate, for a variety of different reasons. Innovation is often important for organisations to say ahead of the competition in rapidly evolving markets, enabling them to meet changing customer demands, improve operational efficiency, and adapt to new and emerging technologies. Sinek (2009) argues that organisations that innovate effectively have a strong sense of purpose as to why they innovate, and are driven by a fundamental mission or cause. It is not simply about creating new products or services, but about finding better ways to fulfil their core purpose and serve their customers.

All of the case study respondents in this project are very much aware of the importance of transport infrastructure and services to their national economy, and the impact that transport has on wider society. Their organisational mission, vision and goals are almost always published on their websites, and their approaches to achieving their goals are often published as formal innovation strategy documents.

The organisations' innovation strategies are explicitly linked to addressing the drivers, whether those drivers are safer infrastructure, improved quality of infrastructure, increased efficiency of the network, or decarbonisation of transport as part of wider climate change imperatives. See Figure 3 for examples of key drivers at various levels, which are synthesised from the literature and from the responses of the case study agencies discussed below.

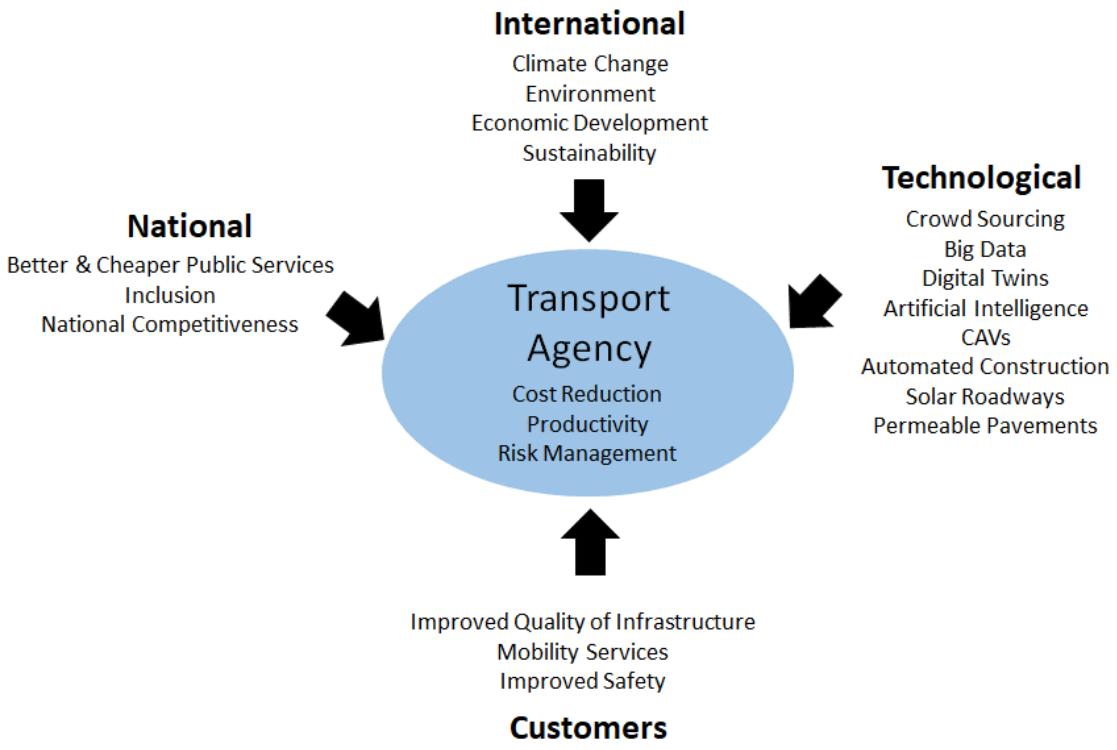

Figure 3. Drivers for Innovation in Transport Agencies

3.2 SPECIFIC CASE STUDY EVIDENCE

The **Chile Smart Cities Unit (SCU)** is responsible for transportation regulation, public transportation infrastructure and operations management, and road safety policy, among others. It is driven by the public by a need to provide safe and efficient transport services, and focuses strongly on active and collaborative citizen participation as part of its innovation strategy. It has demonstrated an ability to listen to and understand people's needs, using feedback to propose solutions with a tangible impact on urban mobility. It feels that when citizens become active and collaborative participants in the planning and design of mobility solutions, then the results can be truly transformative.

The **Ethiopian Roads Authority (ERA)** has been heavily engaged in extensive road construction, upgrading and rehabilitation work to improve accessibility throughout the country. Issues related to quality, time and cost overruns had been observed during this investment programme, and ERA needed to find innovative ways to tackle these problems. One response to this was the setup of a road research laboratory in 2018 focused on identifying innovative technical solutions. Its key innovation partners are therefore listed as other pavement research centres and academia.

The **Indian Roads Congress (IRC)** is responsible for production, dissemination and training of standards, guidelines and codes of practice covering all aspects of road infrastructure construction, maintenance and operations. Examples of recent publications include revisions to geometric design standards, guidelines for high performance bitumen mixes, and guidelines for stone matrix asphalt, development of bus ports, safer commute to schools, and variable messaging signs. Its innovations are targeted towards technical improvements in these areas through review of international standards and guidelines and consultations with national and international experts.

Netivei Israel (NI) is responsible for initiating, planning and maintaining critical transportation infrastructure. It is very conscious of the role of transportation infrastructure in supporting the national economy and its contribution to the social fabric, and actively seeks to identify innovations in engineering planning solutions, advanced work methods, use of digital tools to improve quality and generate time savings, and developing smart transportation systems using big data. It actively encourages 'challenge' proposals from the private sector to provide novel solutions to problems without being prescriptive as to the methods.

Die Autobahn (DA) assumed overall responsibility for the planning, construction, operation, traffic management, maintenance, financing and asset management of all motorways in Germany on 1 January 2021. This means that decades of experience from the 16 federal states are being combined, while new technological developments will be used to shape a modern and innovative company. This will lead to even safer, more efficient and more sustainable transport routes. A significant contribution to this goal is to be made by the development, testing and rapid implementation of new as well as proven technologies and business models with an innovative character for their motorways. Die Autobahn has set itself the goal of further increasing the usability, safety and sustainability of the motorway network, motivated by advanced developments in the fields of renewable energy, digitalisation and climate protection. It also cites an aging infrastructure and lack of skilled workforce as helping to shape its innovation portfolio. The innovation strategy and the Innovation Department of the Autobahn GmBH provides the basis for this work – the "Put innovation first – innovation management at the Autobahn GmbH" sets the strategy to foster major and everyday innovations. In order to bring its founding principles – faster and more efficient planning, building, operation and maintenance – to life, Die Autobahn supports

innovative approaches in road surfaces, structural engineering, intelligent traffic systems and efficient operation. It wants to design an infrastructure of the future that enables the use of new forms of mobility and renewable energies, offer greater safety for employees and users and supports the introduction of new business models. They consider innovation to occur when they modernise their products and processes or introduce completely new procedures.

The **Korea Expressway Corporation (KEC)** is responsible for construction and maintenance of expressways in Korea. Key challenges are cutting edge automotive technologies, the diverse needs of road users, road safety, and climate change, all within the context of decreasing government financial support. KEC is committed to innovating to address these challenges, and has developed a new vision to provide a safe and convenient platform for future mobility using innovative services and advanced technology.

The **Mexican Institute of Transportation (IMT)** carries out research to assimilate, adapt and develop technology for the planning, study, design, construction, conservation, reconstruction and operation of transport infrastructure in Mexico. One of the main objectives of IMT is to "Promote innovation, competition, integration in value chains and the generation of greater added value in all productive sectors under a sustainability approach". It recognises that the creation of economic value is not only reduced to the generation of production using inputs, technology and other available resources, but that the generation of value also depends on innovation. IMT has been dedicated to generating innovation through the development of scientific research projects, studies aimed at increasing the national technological component and the development of technologies that increase productivity in the field of transport to improve the standard of living of the population.

National Highways (NH) (UK) innovation and research strategy recognises its role in the wider context of transportation and mobility, meeting net zero carbon and environmental commitments. It recognises a future of a decarbonised network, and predicts and responds to the needs of all their customers whether they use the road network or not. It also recognises that it is a major client for the UK construction industry. It identifies five key research and innovation themes: design, construction and maintenance; connected and autonomous vehicles; customer mobility, energy and environment; and operations. These themes are interconnected, and not intended to be addressed in isolation. Safety and sustainability are seen to cross all five of their themes.

Oklahoma Department of Transport (ODOT) has since 2020 been undertaking a modernisation initiative aimed at becoming more efficient and effective in its everyday work. It has begun to capture efficiencies through reduction in process steps, introduction of innovative technologies and automation. In 2021, it created an Office of Innovation to guide its modernisation efforts and to help create a culture of innovation. Some of ODOT’s key drivers are to reduce the percentage of structurally deficient bridges on its network, to reduce traffic fatalities, to reduce the mileage of 2-lane rural highways with deficient shoulders, and to increase the total length of highways in good condition. Overall it is focused on improving the quality and safety of its infrastructure within its funding constraints.

The **Uganda National Roads Authority (UNRA)** is in the early stages of establishing its innovation process and structure for management of that process. Its Corporate Strategic Plan (2020/21 – 2024/25) includes development and implementation of a research and innovation programme, and gives clear leadership commitment to this programme. UNRA has developed a policy framework

around which all research and innovation activities will be delivered, and has defined a set of principles, values and doctrines for innovation. These include commitment to in-house, externally contracted and joint R&D; development of projects using 'foresight, insight, and hindsight'; and employment of principles and methods of project management to innovation projects. UNRA's main anticipated benefits of innovation include reduced costs of doing business, investigation of alternative materials for road construction, environmental sustainability for road construction projects, and informed decision-making based on sound research.

Utah Department of Transportation (UDOT) has fostered a robust culture of innovation to address Utah's growing transportation demands and limited funding. Their "good roads cost less" approach has been in place for over 25 years. In 2017, they formalized their innovation program, creating a dedicated division and an innovation team. UDOT encourages employees and partners to find creative solutions to improve transportation and quality of life. They aim to take an "All Users" approach, making transportation safer and more reliable.

The **Vlaanderen Agency for Roads and Traffic (AWV)** has established a Project Management Office (PMO) for Innovation and Change to help drive the implementation of new technologies. One of its key innovation drivers is the rapid development of Intelligent Transportation Systems, which embodies VRTA's commitment to green, user-centric, multimodal, connected, cooperative, and automated solutions, hence it is also establishing a new ICT and Innovation Division. AWV also identifies three important domains within the innovation focus area that are closely tied to the ongoing business: Digital Asset Management, Digital Traffic Management, and the Digital Construction Zone. Its guiding principles emphasize the importance of providing a strategic approach to identifying organisational changes and adjustments to help maintain and even optimise business as usual (BAU) while implementing innovations.

Thus the drivers for innovation explain the "why", and the published strategy documents of the transport agencies explain the "what" of each agency's innovation efforts, and help identify the number and types of stakeholders typically involved in their innovation processes. However, few of these explain the "how" of the innovation process. This project is primarily concerned with the "how".

4. CREATING A CULTURE OF INNOVATION

4.1 WHAT DO WE MEAN BY A CULTURE OF INNOVATION?

Most of the transport agency case studies in this report, and a lot of academic literature, focuses on creating a culture of innovation. A culture of innovation refers to the organisational environment, values, attitudes and practices that encourage the identification, development and implementation of new and creative ideas.

It is about an environment where good ideas and new ways to solve challenges—on a large or small scale—are encouraged. It is about an environment where calculated risks around new ways of doing things can be taken and that, if not successful, then valuable lessons will still have been learned. It is about an organisation where resources are allocated to support new initiatives, instead of people having to work around the system to try new things. Also it is about rewarding innovation through a variety of means, not only monetary but through many other means including recognising and celebrating success.

Key ways of promoting a culture of innovation:

- Encourage creativity
- Embrace failure
- Provide resources
- Recognise and reward innovation
- Celebrate success
- Lead by example
- Promote collaboration

'Accelerating Adoption of Innovation - Technicon Conference 2020' (Mark Fagan)

Overall, building and promoting a culture of innovation requires a commitment from the top, a willingness to experiment and take risks, and a supportive environment that encourages creativity and collaboration. It should encourage individuals to think creatively, challenge the status quo, and contribute to the organisation's overall innovation efforts.

Collaboration has also long been recognised as a key to innovation, not only within an organisation but through collaboration with other government agencies, academia, suppliers and wider industry. Collaboration brings together individuals with diverse backgrounds, knowledge, skills and experiences and so allows for cross-pollination of ideas and innovative solutions that might not have happened in isolation.

Clearly, then, a culture of innovation is affected by many of the policies, processes and day-to-day management of an organisation. As seen later in this chapter, an organisation's structure and human resource management functions can have a significant impact on the way in which innovation is encouraged or sustained in an organisation, and a significant body of knowledge and theory has built up around this aspect. Ideally, innovation would not be limited to specific roles or departments within an organisation, but would permeate across all levels and functions. The organisational structure can be both a help and a hindrance in this regard. Similarly, human resource management is fundamental to almost every aspect of innovation – including staff recruitment, retention, recognition and reward as well as resource and time allocation – and is discussed further below.

For many transport agencies, particularly those responsible for transport infrastructure, the way in which they interact with their suppliers and with wider industry can create significant opportunities for innovation. Given the pace and scale of innovation in the transport sector, innovation in the supply chain is one area which many of the case study agencies are actively embracing.

4.1.1 Encourage Creativity

There are many ways in which creativity can be encouraged, both internally in an organisation, and externally through the organisation's relationship with its national innovation ecosystem including with customers and other stakeholders.

Many organisations use an innovation portfolio to manage and prioritise their innovation projects and initiatives. It helps categorise and assess different innovation ideas or projects based on various criteria to determine which ones align best with their strategic goals and resource constraints. The primary purpose of an innovation portfolio is to provide a structured framework for decision-making in innovation management.

Kennedy describes four types of innovation - incremental, disruptive, architectural and radical – depending on the market and technology involved (Kennedy, 2020). Incremental innovation can be described as making improvements to an existing product or service. Disruptive innovation can be described as an innovation that replaces or threatens to replace an existing technology or approach. Architectural innovations occur when new products or services use existing technologies to create new markets. Radical innovation occurs when new products or services are developed using new technologies to open up new markets. See Figure 4.

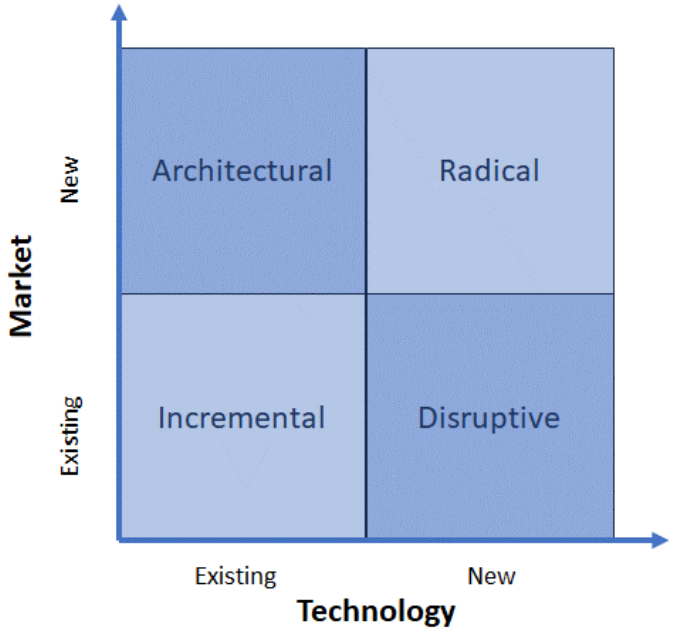

Figure 4.Kennedy Model for Describing Types of Innovation

The transport sector is subject to all of these types of innovation, and all are important. Incremental innovations are often a result of rethinking how everyday processes could be more effective. They would typically emanate from small and simple activities which can generated from within the organisation (either at central level, or from peripheral branches) or from outside the organisation. While they would most often not make the headlines, they can have critical impacts on long-term business goals. An example of an incremental innovation in a roads agency could be the improvement of existing machinery for road maintenance operations.

Architectural and disruptive innovations may originate within the organisation and/or in the supply chain. An example of an architectural innovation in a transport agency could be the application of

Building Information Modelling (BIM) to infrastructure design and construction. A radical innovation in transport, for example, could be the introduction of autonomous vehicles to the public road network.

Disruptive innovations are likely to originate in different sectors or industries. Examples of radical innovations in transport could be the use of artificial intelligence (AI) to transform the collection of data through crowd-sourcing, and the introduction of connected autonomous plant for transport projects.

The key point is that all types of innovation are important, and that an organisation's culture should embrace all types of innovation. It should also be open to innovation ideas from both internal and external sources, otherwise the possibility for innovation may be limited.

Internally, creativity can be encouraged in every individual, in every role or position or job function in an organisation. This is explored further below in relation to human resource management. But in terms of culture within an organisation, if the management in the organisation does not actively encourage ideas, or if they are critical of ideas, or if resources are not provided to help explore and implement ideas, then the culture is not conducive to innovation. Similarly with regards to external innovations - if there are no mechanisms or incentives for suppliers to introduce innovation into their work practices, then opportunities may be lost. For example, there are significant potential savings in time, construction quality and safety from using connected autonomous plant, but if transport agencies do not take the lead in helping pave the way for introduction of new construction standards and practices, then that potential is lost not only to the transport agency but to wider society. Thus many of these cultural aspects are inter-linked, and need to be considered in their totality.

The same applies across approaches to innovation. No agency employs only one approach. In almost of the case studies covered, many approaches are employed within the agency, and these can be extremely nuanced.

In **KEC (Korea)**, as part of a top-down approach, senior leadership has identified four key strategies that it wants to embrace. These are organised around safe and convenient travel, providing novel and innovative services with advanced technology to improve future mobility, and providing a platform for combining multi-modal services with Information and Communications Technology (ICT). It has created technical divisions and specialist groups around the country, for example in emerging technologies such as Unmanned Aerial Vehicles (UAVs), and digital expressways from which it actively seeks to identify and evaluate applications and services. Concurrently, as part of its bottom-up approach, it runs a proposal system in which employees are encouraged to suggest new processes, methods or technologies to improve their day-to-day work processes. It also runs internal annual innovation competitions, the winners of which are selected and put forward for an annual government-wide competition. Thus it explicitly engages with its national innovation agency.

A bottom-up approach can also be considered to include transport users. The **SCU (Chile)** prides itself in its innovation projects based on active and collaborative citizen participation which have been crucial to its success. They successfully tested AI and machine learning (ML) technologies for 5G-connected traffic management, in collaboration with a telecommunications company and transport authorities, and organised communications to showcase the project and its benefits to the general public. The unit has demonstrated an ability to listen to and understand people's needs,

using citizen feedback to propose solutions with a tangible impact on urban mobility. Through innovative methodologies and advanced technological tools, they have transformed their perception of mobility, always prioritizing citizens' experiences and needs.

In the **FHWA (US)**, the State Transportation Innovation Council (STIC) Incentive program and the "Build a Better Mousetrap" program draw awareness to incremental-level innovations, enhancing their potential impact by reaching a target audience of users more directly.

ODOT (Oklahoma) created its Office of Innovation in 2021 with a Chief Innovation Officer and Deputy Chief Innovation Officer, an Innovation Program Lead, and a number of trained contract employees to assist with their innovation initiatives. A set of guiding principles have been established for all employees which includes improved collaboration, enhanced innovation, greater communication, exceptional customer service, increased efficiency, and rapid adaptability, which all contribute to a culture of innovation. ODOT understands that innovations can cause challenge and disruption, and their supervisors are trained to identify and respond to such challenges through their Trailblazer Leadership Program. Also, while considering a new vision, they start with a blank piece of paper mentality specifically to allow more innovative thoughts and solutions.

In **UDOT (Utah)**, culture drives the department's innovations through a mix of top-down and bottom-up approaches. A full-time innovation manager, division staff, and regional coordination council provide outreach to the whole organisation. In addition to promoting a culture of innovation, the programme collects and catalogues fully implemented innovation and process improvement activities. A report of innovation and efficiency accomplishments is published each year. Grassroots development is also encouraged, where employees work within the guidance and approval of their teams to identify and explore innovations. The ethos of "do it yourself" is accepted and encouraged, and evaluation and approval to proceed with implementation is typically left to local team leaders and regional managers. An online system allows employees and transportation partners to share ideas and concepts in addition to reporting on fully implemented practices. The online system provides for sorting and filtering of topics by a variety of criteria to narrow the range of records.

Die Autobahn (Germany) takes a multi-level approach. Innovation priorities are set by the level of the managing directors and communicated through the innovation committee that takes place quarterly (top-down). Managers at all levels are encouraged to try out innovative approaches in their project. Additional funding can be provided through the Innovation Department when project budget is not sufficient to cover the costs of the innovative approach (mid-level). However, every employee of the Autobahn GmbH is able to submit ideas to the innovation prize (bottom-up).

One case study agency which does appear to concentrate more on a top-down approach is the **ERA (Ethiopia)**. Management has focused on innovation and research to improve the quality of road construction and maintenance through new technologies and methods, and to significantly reduce cost and time. ERA has established a Road Research Centre (RRC) as a conducive environment for researchers to concentrate on those specific areas, and in particular to optimise use of locally available materials in road construction and maintenance.

UNRA (Uganda) has established a key set of policy principles to guide its innovation strategy going forward. Its research and innovation projects are driven by UNRA's strategic needs and priorities. The principles advocate a mix of different R&D activities including in-house R&D, externally contracted R&D, and joint R&D to promote a comprehensive approach to innovation. Innovation

projects should also address "foresight, insight and hindsight", emphasizing a forward-looking approach but also taking account of current budget and capacity and learning lessons from the past.

AWV (Flanders) stresses that innovation belongs to everyone on the organisation, and actively advocates for an open and transparent culture of innovation. This includes providing a calibrated channel and process through which every AWV employee can express their ideas about innovation and changes necessary to the business. At the same time there is active collaboration across several different focus areas including national and regional transport bodies especially with regards to connected mobility.

4.1.2 Embrace 'Failure'

In innovation literature, there are clear attempts to frame the outcomes of innovation projects as being a valuable step in a learning process. Projects which are perhaps not immediately successful should be regarded not as 'failures', but as waypoints towards change. Innovation, regardless of the result, contributes to an organisation's collective knowledge, improves resilience, and can be used to refine the approach to solving a problem. After all, the original innovation was intended to address a particular need. If that innovation project was not deemed as successful, the need still exists, and lessons will undoubtedly have been learned which will help refine the approach.

Responses from the case studies indicate quite different language relating to 'failure' among different agencies. The **SCU (Chile)**, for example, has a clear strategy for fostering a culture of innovation, including 'to recognise the value of learning from failure'. This strategy understands that innovation involves risk, and promotes a culture where mistakes are seen as opportunities to learn and improve rather than being punished. Similarly, the **ERA (Ethiopia)** treats projects not as 'failed' but as a learning platform for future works. However, some other agencies include language such as 'unsatisfactory' in their evaluation of innovation projects, and for any projects evaluated as such, a 'corrective action plan' is generated.

UDOT (Utah) stated that it learned more from failures than successes, and emphasised how a lack of a 'blame-game' approach helps to create a culture of innovation. Staff realise that the head of the innovation office applauds innovative efforts, and will provide full backing and support.

The **FHWA** also emphasised that transportation project owners with strong working relationships with their agencies' public affairs are potentially those with better opportunities to effectively cast 'failures' in a more positive and proactive light.

Netivei Israel did caution, however, to 'fail quickly, and cheaply!'. This highlights that any innovation costs time and resources, and that good monitoring and decision-making around innovations is needed to help identify issues at an early stage. This is also linked with their procurement strategy around challenge tenders, as discussed further below.

A clear strategy to embrace 'failure', or to reframe the language around outcomes of innovation projects, will help to foster a culture of innovation, and encourage employees to take on challenges and experiment with new ideas. Also, reframing the language will help cast the agencies in a different light when reporting on innovation activities to oversight organisations or to the wider public.

4.1.3 Provide Resources

The culture of innovation within any organisation is intrinsically linked to the provision of resources. Organisations must not only embrace a mindset of innovation, they must also provide the necessary resources and support systems to allow that innovation to happen. These resources can cover a multitude of different aspects of innovation, including financial backing for trialling or testing new products, access to new technology, access to training and education, or even simply dedicated time for brainstorming.

This section discusses only financial resources, other types of resource are discussed under Human Resource Management on page 29.

An important point to consider is that the level of resources required for an innovation project depends on the innovation itself, so the resource requirement must be evaluated early as part of the evaluation process. This includes the financial, material, technological and human resources required to conduct the innovation project, including any support services around it.

It should also be borne in mind that many innovation projects are specifically designed to save money in the long term. So, although innovation projects cost money, a well-run innovation process should be able to demonstrate significant savings in the short, medium and long terms not only for the transport agency but for wider society. This life-cycle approach to evaluating innovations early, measuring the value of innovation, and the importance of publishing reports of the realised value of innovations, are discussed in more detail in Chapter 6.

Funding is clearly an important contributor to the culture of innovation. However, there are many different aspects to funding as identified below.

The funding sources and levels of funding available to different organisations vary by the type of organisation (whether fully public, fully private, or hybrid models) and according to the national innovation ecosystem in which they sit.

Overall funding available to public organisations will vary with public finances, often with incremental increases every year as public expenditure rises in line with tax revenue and inflation. Public infrastructure agencies in particular are often given 5-year or longer-term budgets to allow them to plan well ahead to accomplish their investment plans. Within such overall budgets, a national agency will likely earmark a percentage of its funding for innovation according to its strategic goals and accompanying innovation strategy.

Funding for innovation is often distributed across the innovation portfolio. **NH (UK)**, for example, allocates 70% of its innovation budget to projects that are likely to realise benefits in the short term (next 5 years), where activities are focused on scaling up and piloting proven innovations; 20% of its innovation budget to projects that are likely to realise benefits in the medium term (5 – 10 years) and where activities will include developing and testing new solutions to meet known or emerging challenges; and 10% of its innovation budget to projects where benefits are likely to be realised in the long term (more than 10 years), and where activities will include exploratory research into possible solutions and emerging trends (see Figure 5). Other case study agencies reported similar breakdown by portfolio, although the percentages may differ.

In **NH**, its Designated Funds plan identifies four funding areas linked to its Road Investment Strategy: users and communities, environment and wellbeing innovation and modernisation; and safety and congestion. Innovation is a cross-cutting theme across all. In addition to the Designated Funds plan, there are many different funding sources or programmes available in UK to encourage or kick-start innovation. These include the UK Research and Innovation (UKRI) which is a government-funded agency that invests in research and innovation across various sectors and disciplines, supporting academic institutions, businesses and collaborations. UKRI also establishes international collaborations with joint funds for research and innovation, with recent joint funding initiatives on earthquake detection and artificial intelligence in India. Other funding sources include funds administered by the Department for Transport (DfT) to decarbonise highway construction; Catapult Centres, which are technology and innovation centres established to bridge the gap between academia and industry, and which focus on specific sectors such as digital technologies, advanced manufacturing, energy, and healthcare, providing expertise, resources, and facilities to support research, development, and commercialisation of innovative ideas. The Connected Places Catapult is the UK's innovation accelerator for cities, transport, and place leadership.

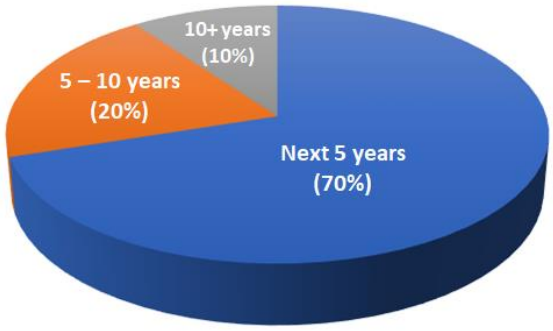

Figure 5. Sample Agency Distribution of Funding for Innovation Projects

Some transport agencies themselves are able to generate additional resources depending on their individual mandates or local incorporations. **IMT (Mexico)**, for example, can develop external project initiatives and can claim back value added tax (VAT) on approved projects, although the administrative process of requesting a budgetary adjustment through its treasury is reported to be cumbersome and is claimed to slow down IMT's innovation activities.

The sources and types of funding often depends on the nature of the innovation. In **KEC (Korea),** officially recognised innovation projects are usually funded or budgeted through the board of directors. These might include for example enhancing electronic charging facilities, developing underground expressways to broaden transport capacity in urban areas, or transferring to electronic tolling systems to improve traffic flow and reduce congestion. Innovations intended to improve internal KEC operations, on the other hand, can be funded through issuing corporate bonds (a mechanism not available to publicly funded agencies).

The sources and types of funding for innovations in the US are many and varied. The **FHWA, UDOT** and **ODOT** case studies reveal a series of funding mechanisms at federal and state level. At a federal level, the Technology and Innovation Deployment Program (TIDP) enabling legislation allows the FHWA to administer a number of following programs, including:

- The Every Day Counts (EDC) program. This highlights market-ready, proven but underutilised innovations that, with widespread adoption in other States, could provide broader benefits and positive impact to the American transportation system. This program tends to fund transformative innovations.

- The State Transportation Innovation Councils (STIC) Incentive program provides up to $100,000 per year per STIC to help institutionalise innovations in a state DOT. This program tends to fund more incremental-level innovations.
- The Accelerated Innovation Deployment program (AID) discretionary grant program provides an incentive of up to $1 million to support the cost of deploying an innovation on any phase of an individual highway project.

At state level, **UDOT's** Innovation Documentation program funds expansion of innovation efforts across the agency. For example, a maintenance station may develop a new tool used to repair signs. When the innovation council promotes the innovation there may be interest by other districts or stations to fabricate additional copies of the tool. The FHWA office in Utah is currently exploring with UDOT the possibility of expanding awareness of innovations from the district level to state level and beyond. UDOT uses a Transport Research Advisory Council (UTRAC) to determine which projects will be funded in the coming year. UTRAC includes workshops to foster ideas from universities and consultants and to evaluate those for funding as research projects. Large initiatives are funded through public processes involving the State's Transportation Commission.

In addition to funds available at a federal level, **ODOT** participates in pooled funding studies with other states and with organisations such as Transportation Research Board (TRB), American Association of State Highway Transportation Officials (AASHTO) and the National Cooperative Highway Research Program (NCHRP) to enhance department knowledge on innovative or topical solutions.

According to the (draft) Science, Technology and Innovation Policy (STIP) (Ministry of Science & Technology, 2020), India's Gross Domestic Expenditure on R&D (GERD) is low in comparison with HICs and many LMICs. The STIP aims to expand the financial resources available in the national innovation ecosystem. It proposed that each department / ministry in central, state and local governments set up an STI unit with a minimum earmarked budget to pursue STI activities. Also that each State would earmark a percentage of the state allocation for STI activities under a separate budget head. It also proposed hybrid funding models with participation from public and private sectors, and the setup of an STI Development Bank for investing in strategic and long-term projects. All of these measures are proposed to strengthen the national innovation ecosystem, improve grassroots participation and overall research and innovation efforts, targeted at strategic themes including societal good, public health, and recycling/waste management.

Die Autobahn (Germany) reports that funding available from different sources from within the organisation (e.g. budget of the Innovation Department) or from external organisations (e.g. national research & innovation programmes). The aim in future is to embed more innovations in the regular project and maintenance budgets of the organisation. Embedding innovation funding into capital projects and maintenance budgets may also help drive efficiencies or allow adoption of state-of-the-art equipment, systems or processes.

Finally here, it is worth noting that worldwide, there is significant activity and interest around innovative funding approaches for transport organisations, in particular for transport infrastructure (CEDR, 2017), (PIARC, 2022). Recent areas of interest include value capture financing which leverages increases in property values and economic activity around new transport infrastructure; green financing which can attract investors who are committed to eco-friendly transport solutions;

blockchain and digital tokens which can enable microtransactions for road usage; and public-private innovations which can bring fresh capital and innovative thinking into construction projects. Each of these approaches may open up new avenues and funding for innovation in the long term.

4.1.4 Recognise and Reward Innovation

Recognition and reward is seen as an important catalyst in creating or sustaining a culture of innovation within an organisation. By acknowledging the contribution of individuals or teams who champion innovative ideas and solutions, organisations not only validate their efforts but encourage and spirit of creativity in others. Rewards, whether in the form of monetary incentives, public recognition, or career advancement, not only honour exceptional performance but also provide a tangible incentive for continued innovation, and contribute to the growth and resilience of the organisation.

Responses from the case studies did not elaborate much on the rewards available to staff or employees. Within the public sector, organisations seemed to focus on rewards as part of annual staff evaluations, where staff who had come up with innovative ideas throughout the year had higher evaluation ratings and may be considered for accelerated promotion. Monetary rewards such as cash prizes were not explicitly identified in the public organisations. KEC (Korea) made the point that 'bold' rewards help bolster innovations in private organisations versus public organisations.

In other responses, **NH (UK)** mentioned a general 'high five' rewards programme associated with staff going above and beyond their normal duties. Similarly, **ODOT (Oklahoma)** mentioned that their rewards programme was not solely for innovative activities, but was mixed with a more general rewards programme based on its Guiding Principles mentioned earlier (improved collaboration, greater communications, customer service etc.) which often revolve around innovation.

4.1.5 Celebrate Success

Celebrating success is similarly seen as an important catalyst in creating and sustaining innovation within an organisation. It may go hand in hand with recognition and rewarding innovation to acknowledge the contribution of individuals or teams, and encourage others in the organisation to be creative.

Only a few agencies in the case study responses mentioned explicit events to celebrate success. **FHWA's** Accelerating Innovation team fosters collaboration among stakeholders through the State Transportation Innovation Councils (STIC) network. The STIC is a national network that brings together public and private transportation stakeholders to evaluate innovations and spearhead their deployment in each State. FHWA convenes this national network several times a year to share information and celebrate successes that the transportation community has achieved in advancing specific innovation goals. Each individual STIC convenes on their own to further drive innovation into practice in ways that best meet their needs. Also, through periodic reviews, FHWA staff at state level identify notable successes to further market and promote the specific innovation in a variety of ways including through newsletters and social media. **UDOT (Utah)** mentioned an annual awards luncheon to celebrate winners for its innovation prizes as a way of exposing and disseminating innovations.

4.1.6 Lead by Example

“Leading by example” in innovation is a leadership approach where leaders in the organisation or a team actively demonstrate the values, behaviours, and practices associated with innovation.

There are multiple ways in which leading by example can be achieved. Those who lead by example are willing to take calculated risks, and will encourage team members to do the same. This relates very much to the ‘embracing failure’ attitude described above. Open-mindedness is another characteristic of leading by example, where leaders are open to different perspectives and unconventional ideas, actively listen to their teams, and encourage creative thinking. They are almost always involved in collaboration and breaking down of silos to promote cross-functional working. Effectively, they embrace all the traits and characteristics that contribute to a culture of innovation as described in this chapter.

4.1.7 Promote Collaboration

Collaboration has been mentioned several times already in this chapter. Clearly, collaboration among different stakeholders, including government agencies, universities, research institutions, and industry, is critical for the success of innovation. Such collaboration can help to create a more supportive ecosystem for innovation, facilitate knowledge sharing and transfer, and promote the development and implementation of new technologies. Examples of different types and methods of collaboration are given later in this chapter.

4.2 ORGANISATIONAL STRUCTURE

The structure of an organisation determines how an entity organises and manages its activities. The structures in an organisation influence and prescribe how activities are assigned, managed, monitored and reported. Due to its fundamental effects on the operation of an entity, various academic authors have found organisation structure to have significant effects on the capacity to innovate.

The results of these academic studies are clear in that adopting flatter, decentralised organisational structures, where decision making power is found closer to those staff who carry out those decisions, is more likely to lead to successful innovation outcomes. Related to this, establishing clear and open communication between decision making staff and staff who action those decisions will also likely lead to better innovation outcomes. There may also be some innovation benefits in adopting less formal work roles, and in not being prescriptive about job functions or positions in the organisational hierarchy.

Several of the case study organisations mentioned how organisational structures impacted their ability to innovate.

KEC (Korea) reported they had adopted a flat structure in order to encourage innovation. They have a director or senior manager responsible for innovation, as well as a managing director and team dedicated to collecting ideas from employees for everyday innovations. For strategic innovations, there is a separate managing director and dedicated division. Specifically for new technologies, there is a CEO-centred team dedicated to investigating cutting edge technologies. And a separate digital expressway promotion division is responsible for incorporation of digital technologies and advanced data-driven solutions into maintenance practices.

It is generally accepted that the management structure of an organisation has an impact upon its ability and success to innovate (McKinsey, 2012).

Cosh et al (2012) examined the effects of organisational structure on small to medium size enterprises in UK, operating both within the technology sectors as well as conventional industries. Companies were grouped by whether they adopted a centralised organisational structure where decision-making primarily occurs at a single point in the organisation, or a decentralised model where decision-making is distributed at different levels or locations. The study also grouped companies by whether employees had formally defined job roles and responsibilities or more informal roles. They found that organisations with decentralised and formal roles were more likely to successfully create and commercialise an innovation. However, when solely considering the technology sector, a decentralised organisational structure and informal job roles was most effective.

Gaspary and Luiz de Moura (2018) analysed a well-known innovative company 3M and found similar results. They found that staff and management at 3M attributed their success at innovation to their decentralised organisation and informal work roles. Beyond this, they found that open and clear communication channels between staff and managers was an important factor in successful innovation. They also explored why highly formalised work roles were a negative factor in innovation, finding that the tasks completed in formalised roles were typically of a low level of difficulty, but with a high volume of work creating time pressure.

Die Autobahn (Germany) has established an Innovation Department that is led by a senior manager with director reporting channels to the director level. It also has an Innovation Board which convenes quarterly, and consists of 50-60 multi-disciplinary participants from across the organisation. Among other objectives, the Innovation Board acts as a sounding board to hear how the organisation is dealing with innovation.

DGC/MITMA has created a Subdirección General de Sostenibilidad e Innovación, whose main role is leading the Innovation Plan. It handles Internal consultation on innovation across the entire DGC, including central and peripherical Services and Units, to address the 10 initial challenges identified by the GC, through Public Procurement of Innovation (PPI). The Subdirección General has designated a network of "focal points" across the DGC (individuals in central and peripherical services) that are particularly interested in innovation, acting as contact points with the Sub-Directorate General and as coordinators. It centralises innovation initiatives, and participate in innovative European projects and follow up other projects.

The **SCU (Chile)** is a multidisciplinary team at the central level that coordinates nationwide technology prospecting projects and initiatives. It has stood out for its innovation projects. Since its creation in 2011, it has led technological development to improve transportation systems in Chile.

In **Netivei (Israel)**, the Environmental, Social and Governance (ESG) organisational unit is responsible for all the aspects of innovation management in the organisation. It includes a research and development department, an ESG department, a strategy department, a transportation models department, the company's chief scientist, and a centre for innovation.

National Highways (UK) has a director responsible for innovation, and a specific head of innovation. It has established an Innovation Hub to encourage innovators to engage with the organisation, and coordinates programmes and initiatives in support of its long-term vision for the strategic road network.

ODOT (Oklahoma) only recently in 2021 established its Office of Innovation, including a Chief Innovation Officer, Deputy Chief Innovation Officer, and Innovation Programme Lead to drive forward its modernisation program.

In **UDOT (Utah)**, the Executive Director has been an innovation leader and promoted disruptive change for over 20 years. In 2017 he made structural changes to the organization by creating a senior leadership role over Innovation and Technology. Department resources were structured organizationally into a matrix focused on advancing mobility and innovation in the state. Under the matrix structure, teams were described as having geographic managers responsible for day to day activities, but who also reported to a set of expert managers who were not geographically constrained and covered a wide range of disciplines, constituting the matrix. The expert managers can facilitate change more effectively as they have greater sight across the organisation. This carries the benefit of reducing the effects of siloing and improving co-operation among teams, without adding additional layers of organisational complexity. The geographic teams may retain the formal work roles and structures required to meet regulatory requirements, however the expert managers roles can be more informal, giving them greater freedom and capability to innovate. The department's Research Division is the agency's formal innovation engine for gathering, reporting, and promoting the innovations and efficiencies that take place.

UNRA (Uganda) is in the early stages of developing its research and innovation programme, and has established the position of a Head of Research and Development. UNRA has developed a policy framework through which all research and development activities will be undertaken. It is establishing a Research, Development and Innovation (RDI) Centre with the intention of UNRA becoming a regional centre of excellence for RDI, and is also establishing a related centre of excellence training facility. As part of these efforts it is also fostering in-house innovation through its Innovation Think Tank to tap into the collective creativity of staff. The Think Tank or "incubation" teams will include informal groups of voluntary communities who are passionate about a particular subject. External partners may also be included with permission of the executive director.

AWV (Flanders) has already established a Project Management Office (PMO) for Innovation and Change, and is in the process of establishing a new Division for ICT and Innovation, to help drive the implementation of new technologies through support services for the rest of the organisation. These support services include providing visibility to their innovations, providing a project approach in terms of project management, providing access to a network of peers, experience with community engagement, specific tools and training, familiarisation with innovative contracts, mentoring, and subsidies.

4.3 HUMAN RESOURCE MANAGEMENT

The human resource of an institution is fundamental achieving the attainment of institutional goals and targets. That is why when it comes to innovation, human resource management cannot be understated. A well-designed human resource management system may be a strong instrument for attracting, nurturing, and retaining individuals with the distinct attributes required to drive innovation in a company.

The literature highlights different approaches being used to fuel institutions' innovation goals and targets from a HR perspective, such as having established leadership, promoting work flexibility, and diversifying the workforce. Also, recognising frontline employees who go above and beyond their usual tasks to encourage everyday innovation to solve practical problems ("brilliant basics") has positive implications on the institution's overall performance with respect to innovation.

The case studies showed various ways in which transport agencies promote innovation. In Utah State (UDOT) for instance, there is a **fully established and structured division** that fuels and centralises innovation within the agency. It contains a team of staff focused on promoting innovation culture, recognising and rewarding achievements, and expanding knowledge sharing to employees as well as transportation partners. UDOT also highlighted the **existence of programmes** to foster the institution's innovation ideas and goals in new entrants. For example, as part of their employee orientation programme, a senior leader meets with new employees and delivers a message regarding leadership support for trying new things and encouraging innovative thinking. Employees at all levels of the organisation are encouraged to identify and develop effective solutions.

There is a lot of literature linking innovation to human resource management. For instance, using a sample of 129 firms across various sectors, Papa et al., (2018) investigated the link between knowledge acquisition and a firm's innovation performance. Their research showed the existence of a positive relationship and the central role that human resourcing plays.

Haneda and Ito (2018) also found that adopting multiple management approaches (such as interdepartmental cooperation, having leads with background in research and development and networking with different research centres) influences employees' propensity to innovate. This conclusion was made in a study that utilised responses from more than 3,000 Japanese firms.

Krammer (2022) has argued that firms are likely to be more innovative if they directly incentivise employees rather than invest in research and other institution-wide investments. This hypothesis was tested using responses from almost 1,000 institutions across the world. The results of the analysis were inconclusive but there was a lot theoretical evidence to back this assertion and data showed that combining different HR strategies could actually enhance employee's propensity to innovate.

There are case studies that also point to different ways through which HR promotes innovation. Enhancing diversity within the team has been identified as instrumental in improving the ideas and products. Promoting work flexibility, i.e., giving employees an opportunity to assist other colleagues across different departments helps to drive innovation (Lazarova, 2019).

In UDOT, individual employees or teams have a **performance requirement** to submit an innovation idea to the Transportation Research Board (TRB) as part of their participation in national training and research. These ideas are tracked by UDOT research division through to implementation. At IMT (Mexico), attendance at courses, congresses, and seminars is considered within the performance evaluations of staff.

Various agencies mentioned that staff in their innovation divisions act as **innovation facilitators**. In Die Autobahn (Germany), there is a formal role of Innovation Facilitator who is responsible for promoting and demanding innovations. Promoting involves establishing a framework for efficient innovation, developing a structured approach to operationalise the innovation strategy, creating transparency in the process, creating space for innovation, and forming collaborations. Demanding involves deepening active idea generation through intensive dialogue with stakeholders and partners, creating new event formats to build a targeted innovation framework, identifying innovation and research needs, developing new 'pitch' formats, and identifying and driving innovation priority topics to set up pilot projects. The FHWA similarly emphasizes its role as an innovation facilitator. It facilitates brainstorming sessions (see page 32), convenes informal gatherings of innovation officers or those with similar roles in other state agencies, helps in review and evaluation of suggestions received, and helps create safe spaces for innovation.

Netivei (Israel) appoints **innovation ambassadors**. These are employees of the company, typically people in each division who have a special interest in the topic, and with key positions that can influence the division's work plans. The innovation ambassadors are able to identify challenges and opportunities within each division to help them find the best solutions. Additionally, they train employees to find challenges in their divisions and on the other hand to be open to opportunities in the market to introduce open innovation. Also, there are incentives for high performing employees.

Apart from financial or promotional incentives, **awards and recognitions** are also important. UDOT holds annual award ceremonies for innovation, which include multiple categories (Spark, Adaptive, Flow awards) to recognize the wide range of innovations that can be achieved. An awards luncheon is held to celebrate winners. A video series of select innovations expands exposure of innovations and provides an accessible and engaging way to learn about ideas. Utah's annual transportation conference highlights and recognizes innovation projects. The ERA (Ethiopia) offers research staff additional benefits and incentives over other staff when hiring and retaining. These benefits and incentives can include provision of housing.

With regards to **recruitment**, for most of case studies, innovation is not directly included in the key stages of the recruitment process unless identifying staff for roles in an innovation division or department. Given that many of the case study organisations run internal innovation competitions or surveys for existing staff, there may be scope for organisations to explicitly evaluate innovative characteristics or attitudes of all job applicants, not only for those positions in the innovation division. Large organisations are moving towards conducting psychometric testing of applicants, with AI scoring of applicants' video presentations and interviews to identify various personality traits. Future recruitment programs may include renewed focus on innovation.

As touched upon in the section on organisational structure, there may also be some innovation benefits in **adopting less formal work roles**, and in not being prescriptive about **job functions** or positions in the organisational hierarchy.

With regards to **staff retention**, humans are, by nature, innovative. An organisation whose HR processes and procedures are seen to stifle innovation may lose creative and dynamic staff. Lack of opportunity for personal and professional growth, or micro-management with little leeway to deviate from accepted procedures, can lead to frustration and lack of engagement from staff. HR policies can help by proactively encouraging staff to be innovative and creative, establishing guidelines for risk tolerance, and including creativity as part of performance evaluation criteria. ERA (Ethiopia) in particular has indicated that a perceived ceiling in a **career path** for researchers has been a barrier to establishment of research centre.

The FHWA Accelerating Innovation office for example, deliberately aims towards creating a '**safe space**' to discuss innovation both as it relates to the project/program level and at the organization's staff/workforce level. If this safe space is established, staff passion about taking **calculated risks** to innovation will continue to grow. Because the transportation industry is generally considered to be conservative, this safe space should also allow for an open discussion of risks and risk management/mitigation strategies. Taking educated and calculated risks should be encouraged; being "risky" should be avoided.

It is also generally accepted that **employee well-being**, mental health and stress levels can impact individuals' creativity. Therefore HR policies and procedures in these areas can contribute significantly to the overall culture of innovation within an organisation.

With regards to **education and training**, all case study organisations provide opportunities for employees to acquire skills relevant to innovation areas, and to stay up-to-date in **technical and non-technical areas** such as the circular economy, sustainability, inclusion or new mobility. Ethics and public integrity play an important part of most government induction and training programs too. **Non-transport subjects**, where transport agencies can make use of innovation from other sectors, such as user-centric design, agile methodologies, and data integration are also important.

The ERA (Ethiopia) highlights the role of **mentorship** by the research director and senior experts to help train junior researchers. ERA also has a **5-year technical support program** with international consultants working at the Road Research Centre to mentor and build capacity.

FHWA identifies other types of technical assistance and education activities, including **training for innovation mentors**, **peer-to-peer learning opportunities**, and workshops. It also highlights the Innovative and Exceptional Partnerships (IEP) programme which seeks to create an effective **pipeline of senior agency leaders** by creating opportunities for dialogue and feedback with state transportation Chief Executive Officers (CEOs). The FHWA's Discipline Support System (DSS) also brings together individuals from technical areas or disciplines across the agency, to strengthen technical training but also to **build networks** for professional growth, collaboration, innovation and **succession planning**. Innovation within the FHWA' DSS can be innovation by knowledge sharing or innovation by design. At the regular Discipline Council meetings, there is a set agenda idea designed to capture innovative good practices from one discipline, with the intention of sharing same across other disciplines. Disciplines are encouraged to help each other take on innovative processes, regardless of whether they've been done before in other groups.

As mentioned earlier, ODOT (Oklahoma) explicitly recognises that innovation often causes **disruption to existing processes**. Its supervisors are trained to identify such disruption under its Trailblazer Leadership Programme. ODOT emphasizes **change management** (preparing the organisation for change) as an important part of innovation management. AWV (Flanders) also

highlights the importance of change management in innovation, specifically identifying the human aspects of change within the organisation in order to try to minimise potential resistance.

Several agencies (e.g. SCU, Chile and AWV, Flanders) also provide **networks to facilitate collaboration** and provide **access to resources and knowledge** among both public and private stakeholders with the express purpose of enhancing innovation.

Die Autobahn (Germany) proactively supports staff participation in **advisory boards of national and international research projects**. This supports the process of bringing research into practice.

Many organisations including ERA (Ethiopia), IMT (Mexico), and NH (UK) provide **scholarships for postgraduate studies** (masters and/or doctorate) in engineering and transport infrastructure disciplines in educational institutions, in both classroom and online settings.

IMT (Mexico) publishes **weekly seminars on innovations** developed at the IMT via a YouTube link which is free to anyone. IMT also seeks to carry out joint support actions on training, liaison, and technical and **technology exchange programmes** with a range of national and international institutions including engineering associations and colleges, asphalt associations, laboratories, federal public administration agencies, national disaster and prevention centers and educational institutions.

One example of innovation of the FHWA's innovation by design is the **table-top innovation** model. A facilitator leads a fast-paced exercise that takes participants from initial brainstorming through to implementation planning in less than 2 hours. Employees are split into teams, given a structured, time-based approach to innovation, and emerge with a path to innovative solutions. Key steps are:

- Form small working groups
- Identify challenges for innovation – brainstorming potential ideas for current practices or processes that would benefit from innovation
- Table voting on 1 – 2 ideas to move forward
- Develop 2-minute pitch presentations or "elevator speeches" to share their ideas with the rest of the groups. The pitch presentations describe the idea, how it will improve a process, how long it will take to implement, and what resources it will require.
- Group voting and Q&A to further refine the ideas most likely to move forward.

These rapid innovation sessions show that positive change can happen quickly and at every level in an organisation.

In UK, National Highways staff are encouraged to access the **Supply Chain Sustainability School** (2023) which is a collaboration between clients, contractors and their supply chains. This is a free virtual learning platform around sustainability, with the aim of upskilling those working with, or aspiring to work within, the built environment sector. It offers training on key topics that are important to the industry including digital, procurement, lean thinking, retrofitting, and project management. Some of the learning material is **continuous professional development** (CPD) accredited.

Thus there is a whole range of training opportunities that can be designed and made available and which can help contribute significantly to the culture of innovation within the organisation.

4.4 INNOVATION IN THE SUPPLY CHAIN AND WIDER INDUSTRY

The gradual shift In the transport industry towards a more open approach to innovation as discussed earlier also applies to the supply chain. Once seen as a logistical operation, the supply chain has now emerged as a focal point for innovation.

Effectively managing innovation in the supply chain requires organisations to not only adapt to market shifts but also to shape the future of their operations. Disruptive innovation in the transport industry, seen in the development and deployment of connected and autonomous vehicles, or in the introduction of connected and autonomous plant in the construction sector, necessitates innovative approaches to engagement with the supply chain.

Also as discussed above, transport agencies have been quite prescriptive in their approach to projects, and have provided highly technical specifications with limited flexibility in their contracts. Under an Open Innovation approach, the supply chain is actively encouraged to participate in all aspects of the project including scoping and design.

Globalisation also means that large supply chain contractors and consultants are able to bring experience and expertise sectors into the transport sector and so help accelerate innovation.

Transport organisations are under increasing pressure to keep up with these innovations to help shape the future of their national economies. Better engagement with the supply chain is key to that.

CapGemini performed a survey of German and Dutch companies to assess their open and innovative procurement practices (2012). They discovered a trend for increasing levels of dependency on external suppliers of services and products. Despite this, they did not find an equal trend for increasing levels of supply chain involvement in innovation or attempts at value chain optimisation.

Companies which practised Open Innovation where they were working collaboratively with other industries or engaging suppliers who were outside of their established procurement contracts were found to benefit from faster innovation and better overall outcomes. CapGemini outlined that in many industries, the suppliers may not be well adapted to an open or innovative approach to procurement, and likely need to develop processes and controls for innovation, as well as expanding their talent pool to include innovation expertise.

A study by Lenderink et al focused on how innovation can be encouraged in procurement for large public civil engineering works (2022). They reviewed construction projects occurring in the Netherlands, selecting 7 case studies where procurement and project documents were reviewed and interviews carried out. From this work they created a framework of recommended practices in public sector civil engineering procurement to improve innovation outcomes, these included: multiple stages of tendering where trials, research and design were separate from the larger main construction contracts; assessing the primarily innovation focused tenders on demonstration of collaboration and innovation competency, with contract values determined by negotiation rather than competition; embedding cooperation (Eriksson, 2008) within contracts, where suppliers which would normally compete are required and incentivised to work cooperatively; and lastly that the client participates actively and shares risk and responsibility with suppliers.

SCU (Chile) promotes **co-design** and **co-creation** among diverse stakeholders, including the public sector, civil society, industries, and academia. This collaboration facilitates the development of more comprehensive and sustainable solutions by combining technical expertise and situational experience from various participants. It also creates **collaboration spaces** to among affiliated organizations to fostering interaction and the exchange of ideas and knowledge. It has also formed a **Public-Private Collaborator Network** of both public and private actors to facilitate collaboration and access to resources and knowledge that can enhance innovative initiatives.

DGC/MITMA (Spain) uses a Public Procurement for Innovation (PPI) mechanism to develop innovative solutions using cutting-edge processes and technologies. In 20221, DGC identified 10 main initial Challenges and then launched the first PPI. As result of the Preliminary Market Consultation, a (surprising) amount (555) of proposals were submitted to address the 10 challenges. The PPI vision is public procurement policy to support private innovation, to motivate the market to innovate to solve DGC challenges. The objective is to implement cutting-edge processes and technologies for present and future mobility, using private-public collaboration capacity for innovative solutions to improve management, and to transform the reality and improve travel. To date, 209 high interest proposals have been selected, and 30 Innovation projects have been identified to develop the proposals (60 % of them to be implemented in the short term) and 30 sub-challenges have been identified.

In ERA (Ethiopia), dedicated **contract provisions** can be used to allow contractors to include budget to support research in their work. This is used especially when constructing trial sections and other research activities. In these instances, the contractor is fully involved in the research work.

KEC (Korea) reports very strict assessment criteria for selection of suppliers by government. However, in many expressway projects, **technical evaluation** can consider some currently important innovative issues as factors for assessment, such as ESG, new technology, safety, convenience of road users etc.

In National Highways (UK), the supply chain is encouraged to innovate through commercial and **contractual** means, with specific clauses added in contracts / frameworks / and tender requirements to encourage innovation. A recent BIM embedment project considered how to institutionalise BIM from a procurement point of view, including **early engagement** in the scoping and design phases, and introduced **new contract clauses** explicitly to reflect BIM terminology. An ongoing project is also working with industry to develop a CAP roadmap (2023) which is considering multiple stages of tendering where **trials, research and design can be separate from the larger main construction contracts** because the implications to contracting and implementation are potentially so radical. The CAP roadmap is also actively looking to **re-balance risk** of CAP between the client and contractor.

UDOT (Utah) has in some cases required contractors to use **specific innovative approaches** to build up a skill base, with these measures being relaxed once a skill base has been established. An example is it requiring contractors to construct bridges using an modular approach where they build adjacent to the site and move into position, as opposed to construction in situ.

Many of the case study organisations emphasise **assistance to startups** through a variety of programmes. Startup organisations are often at the forefront of innovation and can bring fresh ideas to transport agencies with whom they may not have previously engaged. Startups are also known for their agility and speed. Case study organisations who explicitly mentioned encouragement of startups include Die Autobahn, Netivei (Israel), and FHWA (US). Some of these initiatives include "**challenge tenders**", whereby the agency challenges the R&D ecosystem to come up with new ways of doing things. The agency defines the problem, not the solution. In many cases, these types of tenders are required to finish in a short period of time such as 3 months to demonstrate the concept (as part of a principle of "fail fast" as described elsewhere in this report).

4.5 COLLABORATION

In the transport sector, as seen in Chapter 3, the drivers for innovation are a mix of customer, national, international and technological inputs. The challenges across all of these areas require corresponding collaboration at each level, not only to fully define the challenges, but to help identify solutions to deal with them.

National and technological collaborations have been woven through other sections in this report and are not repeated here. This section focuses on collaboration with the customer, and on international collaboration.

4.5.1 Collaboration with the Customer

Collaboration with the customer, whether road user, freight operator, public transport provider, public transport user, or other, has invariably been a feature of most transport organisations in the past. However, there is an increasing number of ways in which customer collaboration can be achieved to involve stakeholders in decision-making processes and governance, as well as in innovation. These methods include digital engagement (e.g. social media, online platforms, mobile apps) ; crowd-sourcing, which involves tapping into collective intelligence to gather information, ideas and feedback ; hackathons and challenges. Open data, helping to make government data accessible and transparent, also helps enable citizens to access information and use it to hold governments to account and to drive innovation. Community-led initiatives can also empower local communities to take the lead in identifying their own local issues and devising solutions. Other methods include human-centric design, focusing on the needs and experiences of citizens using user-centric principles.

Customer collaboration is important not only at the identification or evaluation stages of innovation, but also for measurement of the impact of innovation. Implementing systems to measure the impact of citizen participation in the innovation process, can be important in fostering a culture of openness and transparency.

Many transport organisations have inclusion and equity policies governing their citizen or customer engagement, to ensure that participation is accessible to diverse populations, including marginalised and under-represented groups. Many organisations and in fact national innovation ecosystems have developed legal and ethical guidelines to protect the rights, privacy and security of stakeholders.

The exact role or mandate of the organisation is important in identifying the stakeholders with which it operates.

Of the case study responses, the **SCU (Chile)** explicitly focuses on people and territory. It has adopted a people-centric approach, and promotes a people-centred culture including active involvement and participation among stakeholders to co-create solutions and services that address the real needs of the community. It also incorporates mobility as a key concept in its mission, which enables it to innovate in more efficient and sustainable transport solutions. SCU is also very much concerned with indicators and data, including researching of trends and future scenario-building. Its collaboration with external stakeholders to promote the exchange of ideas and knowledge, which can lead to disruptive innovations.

At a national level, the **FHWA (US)** provides transportation stakeholders (state, local municipalities, tribal councils, cities, metropolitan planning organisations, cities, counties, mayors, coalitions, local public agencies and others) the technical, informational and fiscal resources necessary to adopt and implement innovations. FHWA ensures that communication, collaboration and coordination occurs at all levels possible to support local needs and goals.

UDOT (Utah) explicitly applies an 'All Users' mindset to transportation decision-making, responding to community needs to create a safer, more reliable, and accessible transportation system. The department has an innovation council that collaborates with federal, state, and local partners; as well as formal contractor and consultant councils that work together to enhance transportation innovations and efficiencies.

KEC (Korea) runs a 'people participation program' which asks road users what features or facilities they want in expressways, and request the public to propose innovative ideas and concepts. Innovation is front and centre in its public-facing website, which encourages safe and convenient travel, future mobility, and provision of a platform for multi-modal services with Information and Communication Technologies (ICT). KEC selects the best ideas to improve the outcomes of projects, and also provides prize money in the form of rewards.

4.5.2 International Collaboration

Every transport agency in the case study responses relates some degree of international collaboration.

IRC (India) organises conferences and seminars so that their findings can be used in preparing and updating new standards. In this regard, the International Seminar on Advances in Design, Construction and Operation of Tunnels was organized by Indian Roads Congress on 19-20 April 2023 at Dehradun in collaboration with MoRTH & PIARC in association with International Tunnelling and Underground Space Association. This seminar was attended by 480 participants including 60 foreign delegates from 25 countries. 21 International Experts speakers made the presentations during the technical sessions. The recommendations made in the Seminar will be used in incorporating the best international practices in the relevant IRC Codes.

The **ERA (Ethiopia)** established its Road Research Centre (RRC) in 2018 with the ambition to serve not only Ethiopia but other countries in the region. It has ongoing support and technical assistance from the University of Birmingham in UK.

Die Autobahn (Germany) mentions regular innovation workshops that take place with sister organisations from our neighbouring countries (e.g. the Netherlands, Austria or Switzerland) and, like all European agencies including **AVW (Flanders)** and **National Highways (UK)**, contributes and

participates in CEDR research programmes. Many European National Roads Authorities also participate in PIARC Technical Committees.

Netivei (Israel) reports that it is opening up its tendering processes to international bidding to improve innovation.

Our literature searches and contacts also identified some other international initiatives:

- The Government of Ghana, through the Ministry of Environment, Science, Technology and Innovation (MESTI) is collaborating with the Korean Government through the Science and Technology Policy Institute (STEPI), a research and development organisation, as part of Korea's K-Innovation ODA Partnership Programme.

  The aim of the collaboration is to support Ghana in developing a robust and economically viable Technological Innovation System in the country. The three-year policy collaboration initiative has produced a Master Plan for the establishment and operationalization of the Ghana Innovation and Research Commercialisation (GIRC) Centre and to build capacity in Ghana to execute the master plan. MESTI has the mandate to promote science and technology application in the country and to create the conditions and enabling environment for innovations to occur.

  The PIC brings a set of added values to the agency, through providing visibility to their innovations, providing a project approach in terms of project management, providing access to a network of peers, experience with community engagement, specific tools and training, familiarisation with innovative contracts, mentoring, and subsidies.

  We confirmed with MESTI (October 2023) that there has been no official collaboration yet between MESTI and transport agencies in Ghana, essentially any collaboration with other agencies will be demand-driven by those other agencies. MESTI can provide advice, support and technical expertise relating to innovation policies and processes, subject to funding and government approval.

- In Dubai, the Road and Transport Authority (RTA) has a commitment to enhance innovation in the sector. It currently boasts of over 150 innovation projects. This is being done along 5 main pillars : 1) Supporting and guiding the deployment of innovative products 2) Creating a conducive environment to foster innovation within RTA and through external collaborations. One such initiative is the startup challenge which used an app to solicit design ideas from employees of RTA and visitors to the platform. This was employed as part of the RTA's innovation month. 3) Identifying and developing talent that will propel development. 4) Enhancing processes that utilises innovative products. RTA has also signed an agreement with the University of Birmingham (UK) to establish a Research and Development Centre that will enhance support UAE innovators in the development of latest transport and mobility innovations. Additionally, there is a 5 year strategy, UAE Artificial Intelligence Strategy 2031, which provides a road map and regulations to facilitate the growth and incorporation of artificial intelligence (AI) in RTA's activities.

5. REVIEW OF CONCEPTS AND FRAMEWORKS

The literature review on this project identified several generic processes or concepts representing different aspects of innovation or innovation management. These included ISO 56000 on Innovation Management; the Open Innovation Framework; the Double Diamond Innovation Framework which helps designers and non-designers tackle complex social, economic and environmental problems; and the Oslo Manual which provides guidelines for collecting, reporting and interpreting data on innovation. All of these generic processes or concepts are considered relevant to the transport sector and to transport agencies. This chapter introduces these generic concepts briefly, and identifies any references to them by the case study agencies.

5.1 INTERNATIONAL STANDARDS ON INNOVATION MANAGEMENT

The ISO 56000 series on managing innovation is intended to be flexible and adaptable to different types of organizations, regardless of size, sector, or stage of innovation maturity. It provides a common language and framework for innovation management, which can help organizations to improve their innovation capabilities and achieve better outcomes.

Overall, ISO 56000 is considered to be an important standard for any organisation looking to develop and implement effective innovation management systems. It can help organisations establish a culture of innovation, and form the basis of an innovation management process for an organisation. It has been used as the main basis for the development of the innovation process for transport agencies in Chapter 6.

ISO TR/ 56004:2021 also provides guidance on how to assess the current state of innovation management within an organisation, by identifying strengths and weaknesses and areas where ISO 56000 principles can enhance the innovation process. However this guidance is very generic and we recommend could be tailored to transport agencies.

While clearly many of the concepts and terminologies used by our case study agencies are similar to those in ISO 56000, no case study agency reported familiarity with the standard or any plans to work towards aligning with it or adopting it.

ISO 56000 is a series of international standards that provide guidelines for managing innovation. It includes a set of principles, processes, and tools to support organizations in developing and implementing effective innovation management systems. It consists of several parts:

1. **ISO 56002:2021 - Innovation Management System – Guidance.** This standard provides general guidance on establishing, implementing, maintaining, and continually improving an innovation management system.
2. **ISO/TR 56004:2021 - Innovation Management Assessment.** Provides guidance on how to assess an organization's innovation management system and identify areas for improvement.
3. **ISO 56005:2021 - Innovation management - Tools and methods for innovation partnership**. Provides guidance on how to develop and manage innovation partnerships between organizations.
4. **ISO 56006:2021 - Innovation management - Strategic intelligence management.** Provides guidance on how to manage strategic intelligence for innovation purposes.
5. **ISO 56007:2021 - Innovation management - Idea management.** **P**rovides guidance on how to manage idea generation and selection processes to support innovation.

5.2 OPEN INNOVATION

In the transport industry, there has been a gradual shift from inward looking innovation to a more inclusive approach which does not only consider what can be done with internal resources but what can be externally sourced to enhance innovation.

This openness to innovate with external resources is what is known as Open Innovation. It is a strategic approach that ensures that the process of innovation, i.e., from the development of new ideas to their implementation, is open.

As identified in the literature, it could be in-bound where firms collaborate or partner with external institutions to leverage their technology and ideas to innovate or out-bound where they work with external institutions to market or distribute knowledge and ideas that have been internally generated. See Figure 6.

Historically, transport agencies and in particular infrastructure agencies, have focused on a prescriptive approach to innovation. For example they have updated design guidelines which provide highly technical specifications with limited flexibility. Gradually, they are experiencing a more open approach where citizens, startups, and technology companies are getting involved, and where the supply chain is being encouraged to participate in innovation. Thus transport organisations are thinking in a completely different way. Procurements or tenders are becoming more open to innovation and to alternative methods of collaboration.

From the case study organisations and presentations, only four respondents – IMT (Mexico), DGC/MITMA (Spain), Netivei (Israel) and UNRA (Uganda) - mention aspiration towards an 'Open Innovation approach', although it is clear from responses that many others apply elements of the approach even if they do not explicitly mention it.

Open Innovation is an innovation management concept that has been well researched and promoted in literature. Chesbrough et al. (2003) defined it as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively".

Open Innovation is in contrast to closed innovation where firms develop and promote their innovations using only internally generated resources. This has come about as a result of the need to be more efficient and creative (Carbone et al, 2012). Research has shown that institutions that allow their operations to be permeable (either/both internally and externally) become stronger and often accessible to the wider society (Dalander & Gann, 2010). This presents several benefits which contribute to their performance.

Open innovation may be further categorised by the direction/focus of flow of the knowledge and technology. It could be in-bound, out-bound or a mixture of both. With in-bound innovation, firms actively seek knowledge and technology outside of their organisation. They are more willing to partner, collaborate and utilise products from innovative institutions. Firms seeking external knowledge and technologies could also organise competitions and start-up events. Out-bound innovation on the other hand focuses on the transfer of these internally sourced knowledge and technologies (Lopes & Monterio de Carvalho, 2018).

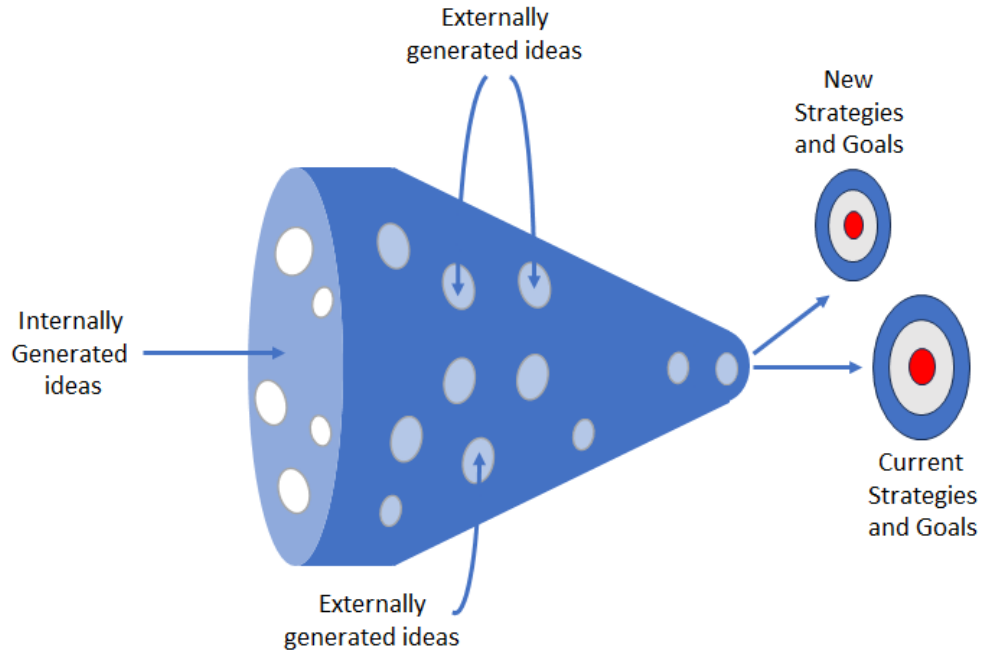

Figure 6. Open Innovation (synthesised from various Open Innovation sources)

DGC/MITMA (Spain) promotes an Open Innovation approach. It recognises that there are major challenges to transform its current practices, and shift its focus from infrastructure management towards mobility management. Historical challenges of the DGC have included lack of a systematic approach to capturing innovation ideas and adopting them. MITMA's mobility strategy of 'Safe, Sustainable and Connected 2030' has several axes including safe and secure mobility, smart mobility, connecting Europe and the world, and intermodal logistics among others, and they are actively looking to collaborate with partners to innovate and implement in these areas.

As part of their commitment to open innovation, **Die Autobahn** elicits ideas for innovation projects from external partners in the private and public sector to submit ideas to their Innovation Department.

IMT (Mexico) explicitly stated that they thought that an Open Innovation approach would help them accelerate innovation, by providing the IMT with external knowledge and technology and bringing the institution's internal knowledge to the outside.

Institutions are also becoming more open to outsourcing work packages to firms for necessary technological and expert skills. **Netivei (Israel)**, for instance, works closely with the Israel Innovation Authority to encourage start-up companies and to promote pilots with them. They also share growth areas and invite start-ups to contribute advanced technology and knowledge aimed at addressing their challenges.

UNRA (Uganda) also explicitly promotes an Open Innovation approach in its Strategic Plan and RDI policy, including leveraging of external expertise and resources. It encourages applied research and development in all aspects of its organisational business.

5.3 MEASUREMENT SYSTEMS

There is no universally appropriate collection of innovation operation measurements. Each organisation should consider its own context, the evolving needs, and expectations of its interested parties, its objectives, and its innovation initiatives to devise its own set of measurements or innovation operation measurements framework.

Traditionally it has been believed that private sector organisations innovate to increase profits or decrease costs, and that government organisations innovate to improve efficiency or to improve user satisfaction, and therefore different metrics are required to measure innovations. The objective then becomes to measure the impact of the innovation in terms of the objectives of that particular innovation. These objectives and their measurement systems must therefore be set early during the innovation process, and measurements taken throughout the process to ensure that the objectives are being met.

The Oslo Manual (2018) is a widely recognized framework developed by the Organisation for Economic Cooperation and Development (OECD) for measuring innovation. It provides guidelines for collecting and interpreting data on innovation activities in organisations. It provides detailed methodologies for measuring innovation inputs, outputs, and impacts, making it a valuable tool for policymakers, researchers, and businesses to assess and compare innovation performance across different sectors and regions. The Oslo Manual promotes standardized data collection and analysis, fostering a better understanding of innovation's role in economic growth and development.

The Oslo Manual can be used to develop a plan for measurement of the impact of an innovation in an organisation. Figure 7 shows an overview of the steps that would be required to prepare a data collection plan, based on the guidance given in the Oslo Manual.

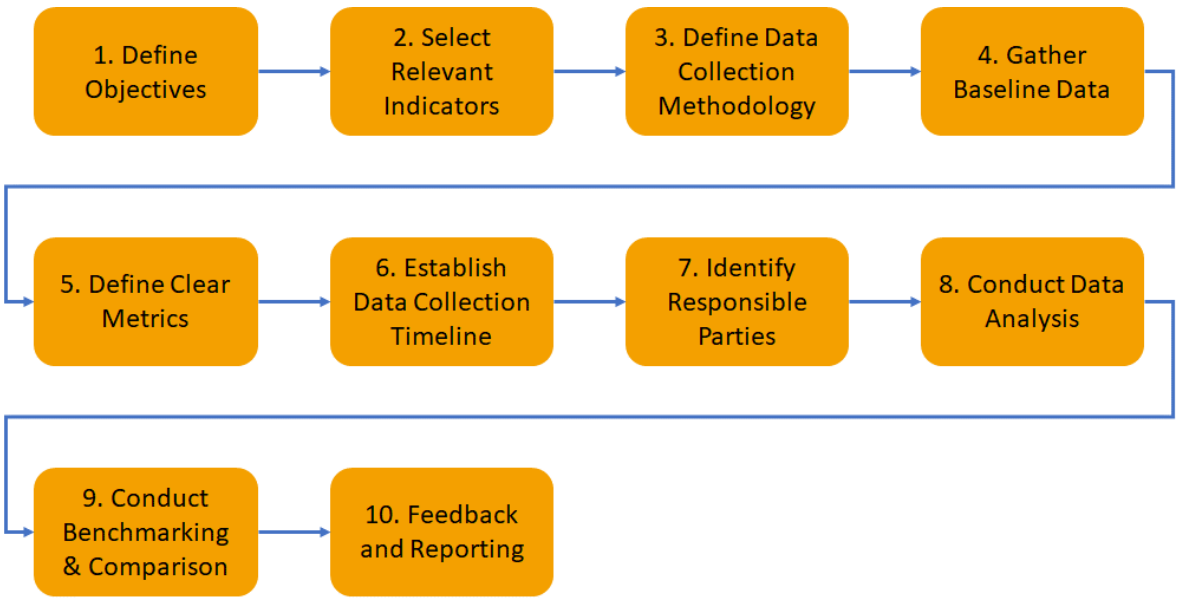

Figure 7. Steps for preparing a plan for measuring the impact of innovation (as derived from the Oslo Manual)

These steps can be elaborated as follows:

1. **Define Objectives:**
   - Determine the specific goals and objectives of your innovation measurement plan. What do you want to achieve through this process? Are you looking to assess the economic, social, or environmental impact of innovations?
2. **Select Relevant Indicators:**
   - Review the Oslo Manual's definitions and guidelines for innovation indicators. Choose indicators that align with your objectives, such as product innovation, process innovation, or organisational innovation. Consider both input (resources) and output (innovation results) indicators.
3. **Define Data Collection Methodology:**
   - Define how you will collect data for each selected indicator. This may involve surveys, interviews, data analysis, or a combination of methods. Ensure that data collection methods are reliable and consistent.
4. **Gather Baseline Data:**
   - Gather any available baseline data related to current processes within your organisation. This can serve as a starting point for measuring changes and impact.
5. **Define Clear Metrics:**
   - Establish clear metrics and measurement standards for each indicator. Ensure that they are quantifiable and aligned with your objectives. For example, you may measure the percentage reduction in time taken for a process due to the innovation.
6. **Data Collection Timeline:**
   - Create a timeline for data collection. Specify when and how frequently you will collect data, and ensure that it aligns with your organisation's innovation cycles.
7. **Identify Responsible Parties:**
   - Identify the individuals or teams responsible for data collection and management. Ensure that they have the necessary skills and resources to measure the data effectively.
8. **Conduct Data Analysis:**
   - Define the methodologies and tools you will use to analyze the collected data. This might include statistical analysis, benchmarking, or other relevant techniques.
9. **Conduct Benchmarking and Comparison:**
   - Use benchmarking to compare your organisation's innovation performance with industry or sector standards. This can provide valuable insights into the impact of innovations.
10. **Feedback and Reporting:**
    - Develop a system for reporting the findings to relevant stakeholders, including management, teams involved in innovation, and decision-makers. Ensure that the results are communicated effectively.

By following these steps and referencing the Oslo Manual's guidelines, an organisation can develop a robust plan for measuring the impact of innovations effectively.

With regards to experience of the case study agencies, most if not all case study agencies reported challenges in monitoring the impact of innovations. In general, it is difficult to measure the impact of incremental or architectural innovation because it builds on existing processes and the impacts may be hard to separate. The impact of new technologies or processes may be easier to monitor.

Some case study agencies gave useful insights into aspects of establishing or running their measurement systems.

SCU (Chile). In the case of emerging services or technologies, their process involves formalizing these advancements so they can be integrated into contractual foundations. This enables the government to effectively award and acquire these technologies.

A vital component of SCU's approach is the comprehensive documentation of all pilots and prototypes through a systematization record. This documentation is essential regardless of the pilot's outcome, as it becomes a valuable repository housing significant insights for the organization.

For example, SCU led a project in 2021 to test AI and ML technologies for 5G-connected traffic management. This project was developed collaboratively with a telecommunications company, integrated into the operational traffic control units' team, who were the project's clients and responsible for validating the solution. Throughout the process, SCU worked closely with the teams, testing use cases. Once these results were obtained, they were presented to the teams and authorities. A communication milestone was organized to showcase the project to the public. Internally, contracts were adjusted to include this technology in the itemized plans. This project won a Latam Smart City Award which recognizes cutting-edge and innovative projects in Latin America in the digital transformation category.

FHWA (USA) describes its process of measurement of the Every Day Counts (EDC) portfolio. Based on the implementation goals determined by each State, FHWA produces a Baseline Report summarizing the details on the innovations in EDC and featuring maps and charts that show the progress expected in advancing the technologies and practices over the next 2 years of the program. After the first year, FHWA will compile a status report every 6 months on the state of practice to track the progress of EDC innovation implementation.

NH (UK) publishes an annual Efficiency Report which measures the efficiency savings as part of its current investment strategy. The investment strategy sets out the expected efficiency savings over its road investment period, and the Efficiency Report monitors whether the expected savings are being achieved. The annual reports summarise the primary evidence that demonstrates the progress towards its savings.

IMT (Mexico) has an indicator for estimating Customer Satisfaction (CS), which is determined from the percentage of stakeholders satisfied with their deliverable, as agreed in the development request for externally-initiated research projects. This index responds to a satisfaction percentage obtained from the service surveys received and is subsequently reported to the Director General during internal control meetings, to monitor and evaluate the progress of the goals. For externally-initiated research services, the CS indicator must be greater than 90%, otherwise surveys rated "Not Satisfactory" should be treated as a "non-conforming" product. Other IMT measures include metrics such as the Completed Research Projects index, and the Completed and Delivered Tests indicator.

In the **IRC (India)**, for innovative materials/technology accredited by IRC, an accreditation committee reviews quarterly performance reports of the materials or technology received from various implementing agencies. The renewal proposals of accreditation are decided based on the successful performance of the product. Based on the long-term successful performance of the product, the same is brought into mainstream through preparation of guidelines and codes.

In **KEC (Korea)**, the chief factors measured are cost-saving, degree of satisfaction of end-users, degree of time-saving in work processes, and the spread of innovations within the organisation or in the stakeholder community.

ERA (Ethiopia) does not use a systematic evaluation approach, however completed innovation projects are evaluated against the benefits and outcomes which were expected at inception.

ODOT (Oklahoma) suggests that measuring employee reaction to innovations is a key way to measure the success of individual innovations and the overall innovation program.

UDOT (Utah) reports that the impacts and benefits of innovations are tracked in four areas that align with the department's Quality of Life Framework: Better Mobility; Good Health; Connected Communities; Strong Economy. Innovation authors submit and report on the achieved benefit of the innovations. The agency publishes this information annually, sharing the impacts of implementing innovations throughout the agency and with elected officials and other stakeholders. Costs saved (both cost avoidance and cost reduction) and labour hours saved are reported and available on a system dashboard.

UNRA (Uganda) performance measures related to innovation are the number of research studies conducted in the approved research areas from its Corporate Strategic Plan, and the number of ideas adopted in these critical areas.

Finally, it is useful to consider the point at which to stop measuring the impact of an innovation. Essentially, the point at which the innovation becomes Business as Usual (BAU) is the point at which to stop monitoring it. Given that some innovations may take years to become BAU makes monitoring and measurement a significant but necessary organisational challenge. An Innovation Management Systems may help in this regard. See Appendix E for discussion on the types of support offered by Innovation Management Systems.

5.4 DOUBLE DIAMOND FRAMEWORK

The Double Diamond Framework for Innovation encapsulates many of the elements of the culture of innovation as described above, including collaboration, creativity, and provision of resources for innovation activities. An overview of the framework is shown in Figure 8.

The framework emphasizes a structured approach to innovation, ensuring that the problem is well-defined and that the solution is user-centred, leading to more effective and impactful innovations. The two diamonds represent a process of exploring an issue more widely (divergent thinking) and then taking focused action (convergent thinking).

The framework is oriented towards supporting individual projects and challenges. Its core processes outline the route from a known challenge to the creation of a viable solution. It is not designed to apply at the organisational level.

There are key aspects of the culture of innovation as described in the previous section that are not mentioned in the Double Diamond framework. For example, it does not explicitly include mention of human resources, procurement, or communications and dissemination. Also, because it is concerned with single projects, there is no mention of creation and management of an innovation portfolio. Finally here, it does not explicitly address risk or risk management in the same way as, say, ISO 56000, which clearly deals with the identification, assessment and mitigation of risk.

The Double Diamond Framework is a design process model developed by the British Design Council from an earlier converge-diverge process model by Béla H. Bánáthy (1997). It is intended to support the development of innovative products and services across private and public sector organisations (Design Council, 2023).

The first diamond represents exploratory and divergent processes to gather information about a challenge or problem to be solved. This includes a "Discover" process where the focus is on understanding the problem by researching and empathizing with users, and a “Define” process where insights are gathered to define a clear problem statement. The second diamond contains processes which are intended to converge to a viable design solutions, it comprises a "Develop" stage, focusing on generating a wide range of ideas and potential solutions, and then "Deliver" where the chosen solution is developed and implemented.

These processes are intended to be iterative allowing earlier processes to be repeated as new information and knowledge is gathered during the development processes. This is supported by a set of user-centric design principles and a “Method Bank” of design techniques.

The overall focus of the Double Diamond framework is designing innovative solutions to user facing challenges, where there are significant elements of engagement between users and the innovation itself. This can limit its relevance to innovations whose users engage in a passive manner, such as developing longer lasting pavement surfaces, or more cost efficient IT systems.

The Double Diamond framework It is not intended as a framework for innovation management in the organisation as a whole, but may prove useful for transport organisations wishing to develop individual innovation projects where a positive user experience is a key outcome.

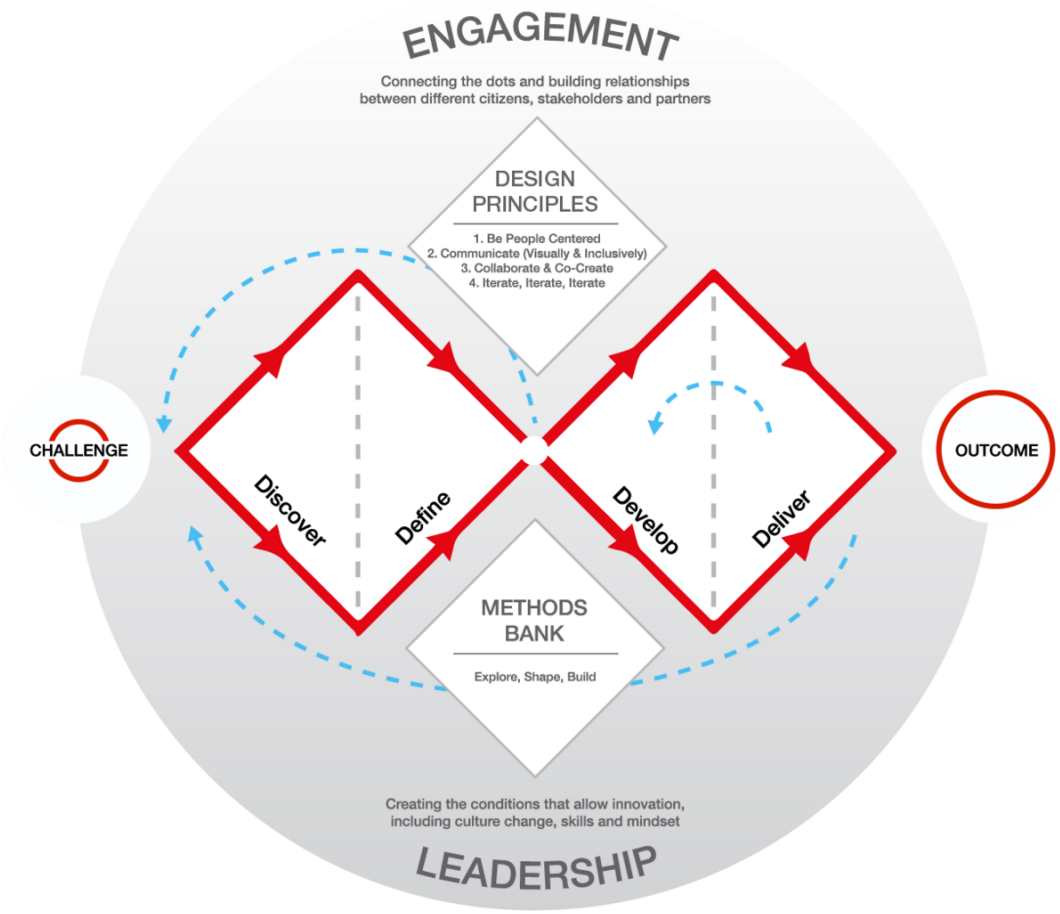

Figure 8. Double Diamond Framework for Innovation

Reproduced here unchanged from the Design Council under Creative Commons License CC by 4.0 Deed

6. INNOVATION AS A PROCESS

6.1 INTRODUCTION

Viewing innovation as a process, rather than as something that 'just happens', has proved a transformative shift in many organisations. This view recognises innovation as a systematic, repeatable set of activities that have defined goals, that can be managed, measured, encouraged, and improved.

Standard process modeling tells us that processes have inputs and outputs, mechanisms and constraints. Viewing innovation as a process akin to that described in ISO 56000 focuses thinking on each of these areas. It identifies the flow of opportunities and ideas in an organisation, the evaluation of those ideas, development and deployment of those ideas as projects, and the value that they create. Viewing innovation as a process also focuses thinking on the policies and procedures necessary to improve innovation, recognises the innovation ecosystem within which the organisation operates, and identifies the people and the support services and activities needed to make it happen including, importantly, the budget.

As discussed above, the Double Diamond approach has key elements of an innovation process, but is more oriented towards design thinking on a single project rather than as an innovation management framework for an organisation. Also, the Double Diamond approach does not fully address many of the issues and challenges identified in the case studies as important to transport organisations, such as risk management (on which ISO 56000 is very strong), or procurement, or human resource management.

Traditionally, transport organisations, particularly road infrastructure organisations, have been structured around a set of core processes (planning, design, construction, maintenance and operations) with a set of support processes (finance, human resources, IT). Defining innovation as a process within the organisation has significant implications for the way in which innovation can work within that organisation.

The project developed a generic process diagram based on a synthesis of the literature and cases studies. See Figure 9. This was adapted and expanded from ISO 56002:2021 Innovation Management System Guidance. We use this as a framework for discussion of best practice or good practice as identified in this project. Some of this best practice has been described already in this report under creating a culture of innovation. This chapter shows how the culture of innovation in an organisation, and the ecosystem within which that organisation operates, mould the way in which such processes and activities operate. It is hoped that the process and examples shown here will give inspiration to those transport agencies that are setting out on a journey of formalising innovation, and to those that are looking to improve the way in which they currently conduct innovation.

Figure 9 depicts a core innovation process in an organisation, as the four orange boxes Identify Innovations, Evaluate Innovations, Develop Solutions, and Implement Solutions. The inputs to this core process are the Opportunities (coming in from the left), and the outputs are the Innovation Value (coming out on the right), emphasizing that innovations should be deployable and should add value to the organisation. The grey 'funnel' in the background indicates that potential opportunities are gradually whittled down to actual solutions through the evaluation process which will undoubtedly weed out some innovations as non-viable at least for present.

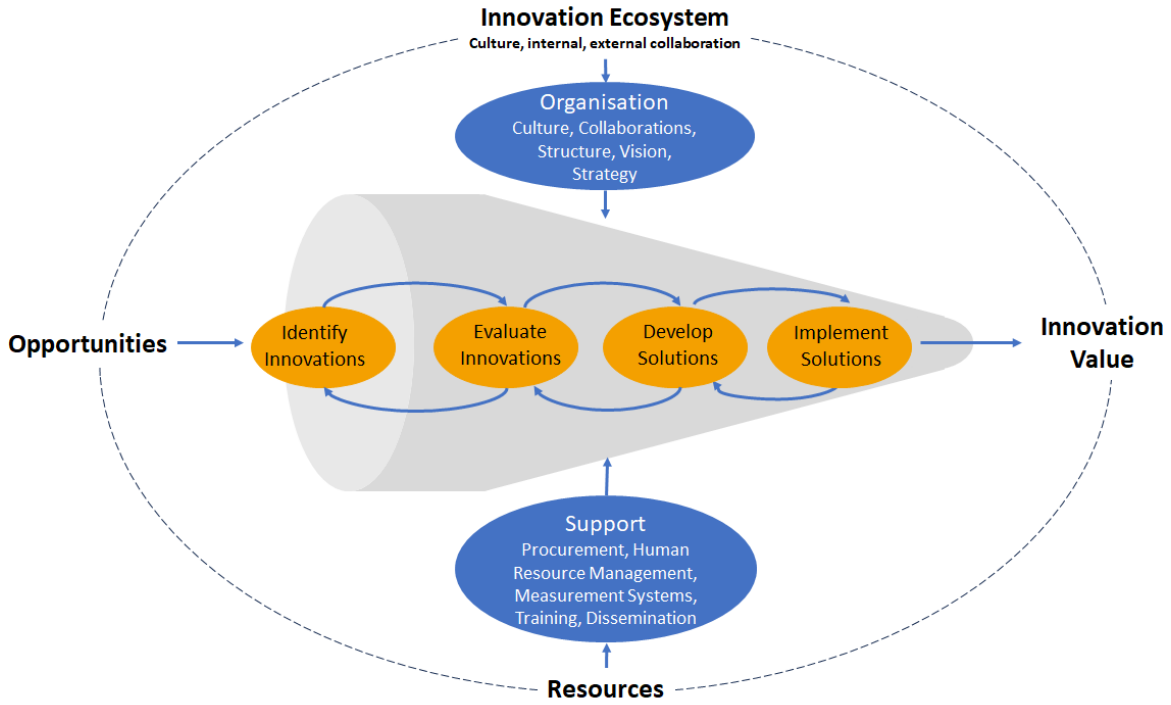

Figure 9. Innovation Process in an Organisation (adapted and expanded from ISO 56002:2021)

Although the overall process is left-to-right, there are of course feedback loops within that process as various opportunities provide ideas that perhaps spawn other ideas that need to be evaluated separately, or solutions are developed which later need to be refined and re-evaluated before going on to development and implementation.

The Innovation Ecosystem at the top of the diagram represents the national ecosystem within which the organisational ecosystem functions. The Organisational ecosystem sets the tone for the culture of innovation nationally, and may provide national resources including funding, training and services. The Science, Technology, Innovation and Policy (STIP) reviews developed by the United National Conference on Trade and Development (UNCTAD) are a very good starting point to describe the national innovation ecosystem of a country.

The Support Processes at the bottom of the diagram show a number of activities as described above in this report, including procurement, human resources, training and dissemination.

Note that the outer circle or oval represents a cycle of continuous improvement. This can be envisaged as a Plan / Do / Check / Act (PDCA model), also known as the Deming Cycle. The PDCA model is a systematic framework for continuous improvement and quality management. Organisations can apply this model to various aspects of their operations including product development and process optimisation. It provides a structured approach to drive improvements in a systematic manner, and aligns with principles of Total Quality Management (TQM) and continuous improvement methodologies like Lean and Six Sigma.

Figure 10 shows the same core innovation process as shown in Figure 9, with the key inputs to and outputs from each sub-process added. The inputs and outputs to each of these sub-processes are described in the subsequent sections in this chapter, along with examples from the case studies for illustration.

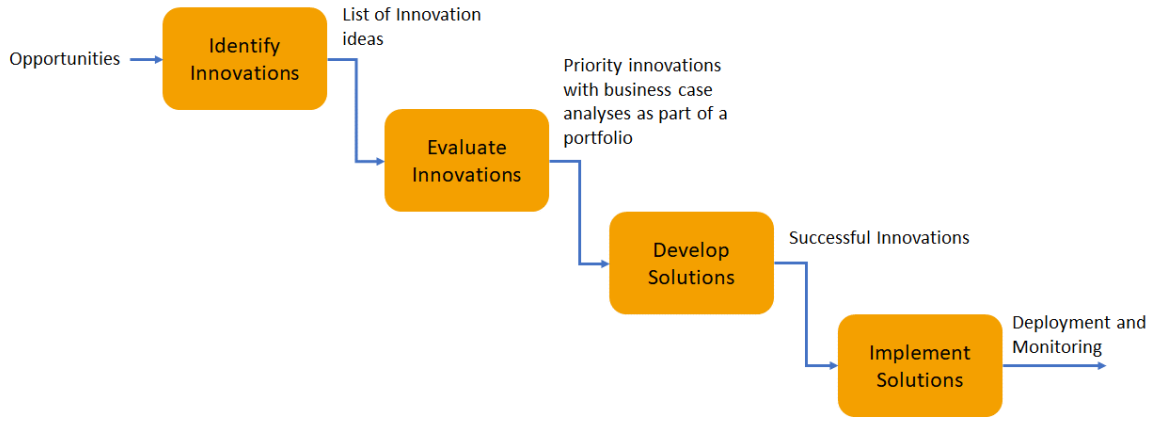

Figure 10. Core Innovation Process with Inputs and Outputs

6.2 IDENTIFY INNOVATIONS

The first sub-process in our innovation framework is to identify innovations. The opportunities for innovation usually go hand-in-hand with or are aligned with the business strategy, which identifies the key challenges, priorities and goals for the business over specified timeframes. Opportunities to address these challenges can be derived in many different ways depending on the openness and remit of the organisation (e.g. foresighting reports, user surveys, calls for ideas etc. which are discussed further below). The list of innovation ideas is then put forward for evaluation within the organisation. The sub-process to identify innovations is summarised in Figure 11.

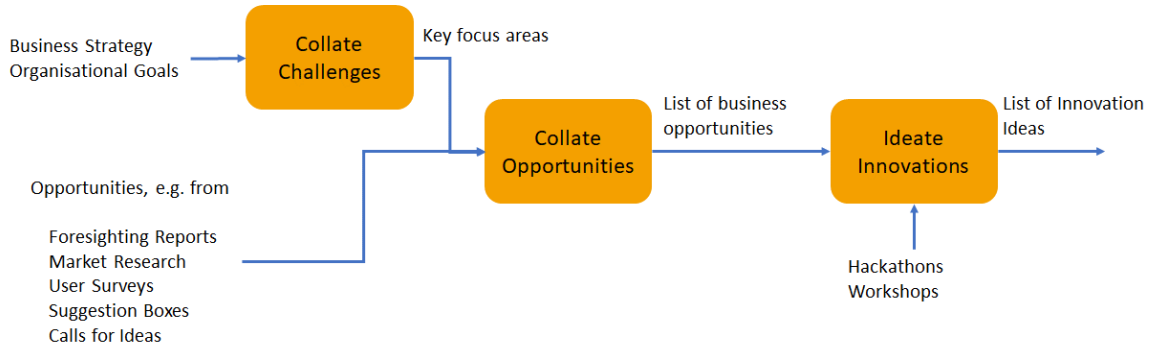

Figure 11. Identify Innovations

6.2.1 Collate Challenges

The initial collation of challenges is important because it aligns the innovation under consideration with the business strategy and organisational goals. It is also the 'hook' in the process in which to consider the type of involvement that the transport agency will play in the innovation.

The TC 1.1 report on the Role of Transport Agencies in Shaping Disruptive Technologies (PIARC, 2023) identifies different roles of transport agencies in shaping disruptive technologies and service models. These include Policy Maker and Regulator; Researcher and Developer; End User, Operator and Manager; and Convener, Enabler and Integrator. The report also outlines a series of strategies and actions for transport agencies that may include policy and strategy development; development

of legal, regulatory or governance frameworks; technical development and implementation; and internal organisational changes and capacity building.

For major disruptive innovations, such as connected and automated driving, different transport agencies in different countries may take different views on the level of infrastructure support that they are willing to provide, which will determine the types of innovation that will need to design and deploy. Roads agencies may not be at the forefront of leading the disruption, but they will be involved in helping to regulate it and provide support for it. In other examples of disruptive innovation, such as automated construction, transport agencies may be instrumental in bringing together the necessary stakeholders to help create the frameworks within which such innovation can take place. Such activities will at least initially be based on collaborative workshops rather than any technical innovation.

6.2.2 Foresighting

Foresighting (sometimes called horizon scanning) covers a wide range of activities which aim to predict future opportunities, challenges and risks. This might focus on technology, where study of technological development in adjacent industries or academia allows inference of what technological advancements may occur within the highways sector in the future. For example, considering commercialisation of automated plant in the mining sector it could be expected that similar technologies could be developed for highways in the future. Foresighting might also focus on social, environmental and economic issues. In these instances, foresighting might analyse hybrid or remote working trends to estimate future transportation demands among a population.

Conducting foresighting is important because it allows a transport organisation to anticipate opportunities and challenges, and begin preparations in advance to achieve better outcomes. Where foresighting identifies an opportunity, a transport organisation may be able to take action to accelerate its arrival. An example of this came from **National Highways (UK)**, where they recognised the benefits autonomous plant can bring, and subsequently developed a Connected and Autonomous Plant Roadmap to accelerate adoption (TRL, 2020). **Die Autobahn (Germany)** gives an analysis of 7 disruptive technologies for a shorter-term horizon from 2023-2028, including metaverse, flying cars, ‘digital humans’, blockchain, wireless electric vehicle charging, and disposable technology.

Early identification of future scenarios allows a transport organisation to establish a position and exert influence on key decision makers to encourage favourable outcomes.

There are multiple methods of foresighting. The pathway chosen will likely depend on the organisation’s culture and wider innovation ecosystem. Where an organisation has its own innovation group or staff with capacity, foresighting activities may be carried out in-house. The **SCU (Chile)** for example reports carrying out foresighting activities in-house to challenge and validate projects and proposals against future needs and requirements. Similarly, **Netivei (Israel)** reports using foresighting to anticipate and prepare for future trends. **KEC (Korea)** has several divisions to detect future trends and developments including changing road users’ needs. Each division is required to research current trends and coming environment change factors in order to influence new management direction. **AWV (Flanders)** reports using services such provided by Gartner and McKinsey among others to gain insights into wider non-transport technology direction.

Transport agencies may consider creating an innovation department or role to carry out foresighting activities, however some case study organisations report difficulties in creating new staff positions or roles. Foresighting services may also be offered by consultancies within an organisation's supplier network, as part of an ever-growing Innovation-as-a-Service market.

National government may also provide foresighting services and analyses to transport organisations. For example, the UK's Government Office for Science maintains a database of emerging technologies and it makes available to public bodies (UK Government, 2023). The **IMT (Mexico)** also cites the 'Guidelines for the Technological Roadmap of Land Transport in Mexico, Vision 2021-2050', a Mexican government analysis of future transport needs and a roadmap towards meeting them (Government of Mexico, 2023). The IMT reported using the analysis within to guide the development of their own strategy.

6.2.3 User Surveys

As seen earlier in this report, many transport organisations conduct user surveys to get innovative ideas from their staff and from external stakeholders. Both staff and external stakeholder surveys are important to involve the users in the creative journey, to gain fresh perspectives, to validate concepts, and to ensure that any solutions developed actually resonate with users.

The level and extent of user surveys reflects the openness of the organisation to innovation. Surveys can be scheduled for example annually or more regularly for certain applications. Examples from the **SCU (Chile)**, **KEC (Korea)**, **NH (UK)**, and **UDOT (Utah)** are given elsewhere in this report.

6.2.4 Suggestion Boxes

Suggestion boxes can be physical or digital mechanisms for collecting suggestions from a group of people. They can be used to generate a wide range of ideas from a diverse group of participants. Depending on how they are implemented, they can have a low barrier to entry, and can help cultivate a sense of engagement with the participant groups.

They can be opened up to staff within a division, or an organisation, or indeed opened up to the general public. They can be very specific, focused on one question, or can be made more general.

6.2.5 Hackathons / competitions

A hackathon is an event, typically lasting for a day or more, where individuals or teams of developers, designers, and other professionals come together to collaboratively work on innovative projects. These are often centred around software development or technology solutions but can include policy or strategy development. The term 'hackathon' is a blend of 'hack' in the sense of exploratory programming or creative problem-solving and 'marathon', implying a long focused effort.

Hackathons allow new ideas and concepts to be developed whilst bypassing normal restraints, such as staff time or bureaucratic processes. They allow persons with key talents and skills to mix together for just long enough to produce results before they return to business as usual (BAU).

There are more variable elements of hackathons which must be considered against the desired outcome. The invitees may be internal to the company, external, or a mixture. The event may be by invitation only, or open to all. **NH (UK)**, for example, conducts hackathons to support their innovation activities. In one such activity they arranged an open hackathon, supported by the Connected Places Catapult (a government innovation organisation). This hackathon developed

novel ideas for using highways data from stakeholders who would otherwise have limited input to policy and innovation development (Connected Places Catapult, 2019). **Netivei (Israel)** also quotes experience in hosting hackathons to foster innovation. As part of their process they offer post-hackathon mentorship to enable and encourage further development of the solutions which emerged from the hackathon (The Funnel Magazine, 2020).

Die Autobahn (Germany) regularly participates in innovation competitions. As an example, it participates in a co-innovation program with Deutsche Bahn, the DB Mindbox. The DB Mindbox is a 100 day guided accelerator program of Germany's state-owned rail infrastructure provider. It is organized in batches of various use cases for which startups can apply with their solution. The Autobahn GmbH is already participating for the second time and is benefiting from a proven and well-experienced way of engaging easily with startups. Through the structured way forward, innovation potentials can be tested across different modes. It also cites three other examples:

- It is conducting a joint market exploration with ASFINAG (Austria) to generate innovative ideas for energy storage on service stations. A public tender platform from Austria has been used to solicit public tenders, as part of a low-complexity application process with clear instructions and deadlines.
- It is running a hybrid hackathon for data-driven innovations for the Autobahn which is open to anyone with ideas for innovative software-defined vehicle solutions. Students, experienced developers, or simply mobility enthusiasts can submit their ideas and become part of the digital.auto community.
- It is offering a European start-up prize for Sustainable and Digital Highway Infrastructure, to accelerate the transition to a more sustainable digital highway infrastructure through new materials, processes and EV fast charging.

6.2.6 Calls for Ideas

FHWA most recently posted a call for ideas for innovations for consideration in EDC in March 2022. Suggestions were welcome from within FHWA as well as primary stakeholders such as AASHTO and other transportation agencies and organizations, as well as the general public. Those responding to the call were asked to provide feedback on the noted "Innovations of Interest" and provide other proposals. Respondents were asked to consider how the innovation or process contributed to the following:

- National Impact: How will it benefit the transportation system nationally?
- Game-Changing: How is it transformative in making our transportation system adaptable, sustainable, resilient, equitable, and safer for all?
- Urgency and Scale: How will it positively impact the environment, safety, congestion, freight movement, construction techniques, contracting methods, project costs, maintenance, preservation, or emergency response?
- Readiness: Whether there are supporting specifications, guidelines, or procedures available to support technology transfer and national deployment.

6.3 EVALUATE INNOVATIONS

The second sub-process in the framework is to evaluate potential innovations to estimate the value they could bring to an organisation in the short, medium and long term. This evaluation sub-process is necessary to ensure that budgets are expended on ideas that are important to the organisation, and also recognising the long-term goals and strategies of the organisation. Most if not all transport agencies already have in place cost/benefit analysis and risk analysis frameworks with which to make this evaluation. Also included in this evaluation process is the concept of Technology Readiness Levels (TRLs) which are systematic methods for evaluating the maturity of technology. These three aspects then feed into prioritisation of the innovations for development resources and funding. Prioritisation can be achieved through a mixture of reporting, analysis, voting, and collaboration and, as we have seen with other sub-processes, the method of prioritisation depends strongly on the culture of the organisation. The output of this sub-process is an innovation portfolio. As discussed in Chapter 5, the innovation portfolio is likely structured by short, medium and long term innovations, and by the type of innovation (sustaining, incremental, disruptive, and radical). The sub-process to evaluate innovations is summarised in Figure 12.

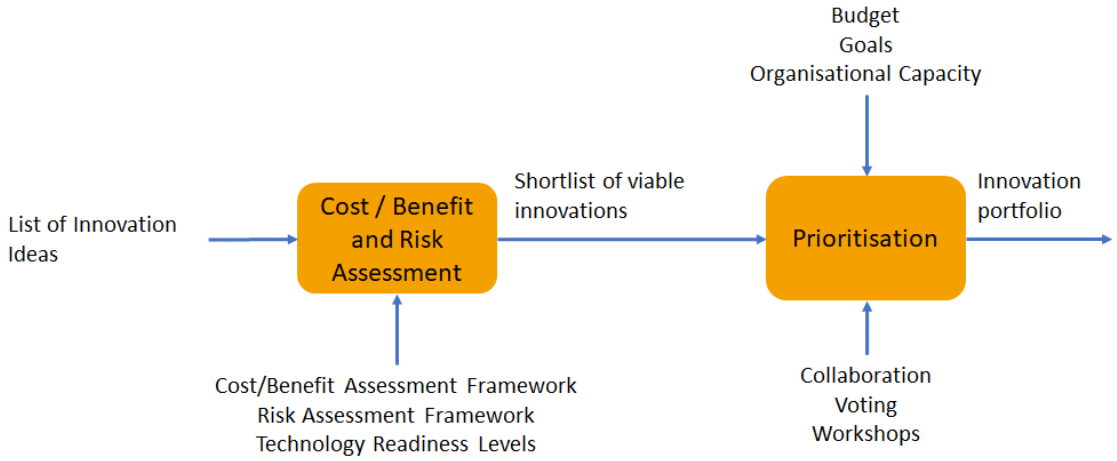

Figure 12. Evaluate Innovations

6.3.1 Cost/Benefit Analysis

Cost-Benefit Analysis is a systematic method for evaluating the economic viability of a project by comparing the costs of implementation with the potential benefits it can generate. It can be used to evaluate whether the benefits of a given innovation outweigh the costs of that innovation, and to compare the costs and benefits of different innovations.

Costs can include the initial research and development, and the ongoing costs over the lifespan of the project being considered for implementation. Benefits can include direct benefits generated by the project, for example reduced survey or inspection costs, as well as indirect benefits such as improved safety to workers or reduced environmental impact. In the case of **UDOT**, impacts and benefits of innovations are tracked in four areas that align with the department's Quality of Life Framework: Better Mobility; Good Health; Connected Communities; Strong Economy.

Cost-benefit analysis may also include sensitivity analysis to evaluate the impact of different assumptions on the costs and benefits.

Most national governments and national agencies have detailed requirements or guidelines for cost-benefit analysis, for both infrastructure projects and innovations to ensure that cost-benefit analyses are conducted in a consistent and transparent manner, and describing the types of economic and non-economic factors that should be included (e.g. UK Treasury Green Book, (2022)). The overall concepts of CBA methodologies are widely applied, but there are distinct differences in the details across national governments.

Netivei Israel (NI) explicitly obtains expert opinion when evaluating benefits of innovations, including for example time and fuel savings from novel products, and environmental and social impacts. Still in NI, all potential innovations are assessed by their financial division.

Die Autobahn (Germany) primarily involves experts from different organisational units for evaluation of innovations, to help ensure that innovations areas are supported by different organisational levels.

Many agencies publish detailed results of their calculations, which also helps address transparency and accountability of their innovation programme. **UDOT** for example has published detailed information on its methodology for calculating benefits of materials innovations, including for Portland Limestone Cement, Recycled Asphalt Pavement, and savings in VOC emissions using different types of paint for road markings (UDOT).

6.3.2 Risk Assessment

At this stage of the evaluation process, risk assessment is about identifying the key risks of an innovation, and identify and categorising the types of activity that would be affected by the innovation. It can form the basis of a risk assessment plan for the innovation if approved.

IMT (Mexico) carries out a Strengths / Weaknesses / Opportunities / Threat (SWOT) analysis at institutional level, based on the guidelines of the National Development Plan 2019 - 2024 and the IMT Sector Programme. This detects potential weaknesses and threats derived from political, economic, social, technological, ecological and legal factors with the intent of minimising risks and their negative impact on the Institute's performance. Each research project has a risk management procedure in which risks are identified, qualitatively analysed and a risk response plan is generated.

Netivei (Israel) develops a Risk Map for potential innovations, and explicitly considers lessons learned from previous projects. Different types of risk evaluated include regulatory, financial and reputational risk, as well as geopolitical risks for it supply chain.

NH (UK) publishes general guidelines for safety risk assessments (GG 104 Requirements for Safety Risk Assessment, 2018). These include the initial stages of risk planning and categorisation, as well as risk mitigation and measurement which cross into the development and implementation phases.

Die Autobahn (Germany) primarily relies on expert opinion for judgement of risk.

Some case study agencies are very risk-averse to evaluating new technologies. **ERA (Ethiopia)**, when considering innovations with no prior use in Ethiopia, will not implement an innovation which is assessed as having any risk whatsoever.

6.3.3 Technology Readiness Levels

The Technology Readiness Level (TRL) is a systematic method for evaluating the maturity of a technology. It involves evaluating a technology against a specific set of criteria to determine its readiness for implementation. Use of TRLs is widespread across many industries. The EU introduced TRLs in 2012 to determine the development or maturity of a research and its readiness for market uptake and potential investments. This is a generic TRL scale which was introduced in EU funded projects in 2020 and is the point of reference for determining the development or maturity of a research and its readiness for market uptake and potential investment.

TRLs can be considered to be subjective, however they can be tailored for sectors or organisations to reduce subjectivity. Transport Infrastructure Ireland (TII) produced 'Guidelines for the Implementation of Innovation' (2020) to provide a consistent approach to the assessment of readiness of potentially innovative products and processes. The TII guidelines include TRLs specifically devised for the agency, which is responsible for management of road and light rail networks. The guidelines provide a clear path for products or processes to move through the TRLs towards deployment as a pilot or trial. **National Highways (UK)** also recognised that it needed technical innovation to meet its performance targets for its next Road Investment Strategy (RIS), and used TRLs to assess the maturity / viability of technologies to reach those targets.

Table 3. Technology Readiness Levels in EU projects

TRL level	Description
9	actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)
8	system complete and qualified
7	system prototype demonstration in operational environment
6	technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
5	technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
4	technology validated in lab
3	experimental proof of concept
2	technology concept formulated
1	basic principles observed
Unknown	TRL level can not be estimated due to the lack of information

Source: European Commission

6.3.4 Prioritisation

As with other processes, prioritisation of innovations can be conducted in a number of different ways, depending on the culture of the organisation and the type of innovation. For example, innovations may be selected by management committee, by peers within the organisation, by a vote open to all staff, or even voted upon by road users or other stakeholders.

In **IMT (Mexico)**, all innovation projects generated by IMT researchers must be approved by a majority vote of the Selection Committee for Internal Initiative Research Projects (COSPII). This aims to ensure the quality of the research projects developed at the Institute, in accordance with the current lines of research. The COSPII is made up of the IMT Coordinators and at least one representative of the Secretary of Infrastructure, Communications and Transport, coming from the Undersecretariat of Infrastructure, Undersecretariat of Transport or the Coordination of Advisors of the Secretary of the branch. At the end of the committee session, the chairman sends the opinion to the Director General for his consideration, as the person responsible for authorising the annual programmes of the technical areas in the field of scientific research and technological innovation projects, by reviewing their alignment and concordance with the institutional strategic plan with the aim of providing results that support the comprehensive development of the different modes of transport for the benefit of the country. In other words, the Institute's staff cannot implement innovations without prior authorisation from COSPII and the Director General.

KEC (Korea) has explicit processes depending on the type of innovation being considered. Its Everyday Suggestion program includes a 3-step process of voting, where candidate innovations are first voted on by the workforce through a mobile app, winners are put forward to a mid-level evaluation committee, and finally to a committee composed of managing directors. For strategic innovations, a 2-step process is used, with the first step comprising a special committee composed of dedicated team leaders from related fields within the company, who will review candidate projects and make adjustments as necessary; the second step in strategic evaluations is conducted by a final committee composed of outside specialists, executive directors and the CEO.

In the **ERA (Ethiopia)**, innovation projects are selected by the Research Director and their team. They prepare a proposal for the innovation considering costs, benefits and outcomes of the project. These proposals are assessed by the Research Management Committee, comprising executive members of the ERA.

In **FHWA**, the FHWA Accelerating Innovation team facilitates the review and evaluation of suggestions received from their aforementioned Call for Ideas, relying on the technical expertise of agency experts, and refines the list of potential innovations for final consideration. This includes analysis of risks, including the impact to internal resource bandwidth if selected to lead a deployment team through a two-year implementation cycle. Additionally, resource considerations on the behalf of the agencies potentially implementing the innovations (i.e., State and local agencies) are also heavily evaluated. The FHWA Executive Leadership (Administrator, Deputy Administrator (appointees) and Executive Director (senior career staff) convene a meeting with executive level representatives from the key United States transportation organizations (e.g., AASHTO and others) to discuss the list of proposed innovations. These stakeholder meetings are not intended to achieve consensus on the topics. Rather, FHWA seeks to receive indications on whether the proposed innovations will serve the “greater good” of enhancing transportation programs and projects at the national level. Based on the feedback received from these stakeholders, the FHWA Executive Leadership makes the final decision about the innovations to include in the EDC program cycle, with the Accelerating Innovation team managing the overall program delivery activities.

For the core FHWA technology deployment programs (EDC, STIC and AID Demonstration), they do not require proofs of concept for advancing innovations. FHWA refers to the TRL of the innovation

as an indicator for inclusion and eligibility in certain programs. For example, innovations promoted through the EDC program typically are at the TRL level of 9 (i.e. the technology is deployed in its intended operational environment; information about the technology is already disseminated to the user community; and the technology is adopted by the user community).

However, one of the evaluation criteria for an AID Demonstration grant award and STIC Incentive projects is whether the proposed innovation is at a TRL level of 7 or greater (i.e., available components are representative of production components; the fully integrated prototype is currently demonstrated in an operational environment (real-world conditions, including the user community); and all interfaces have been tested individually under stressed and anomalous conditions). This criterion has occasionally enabled applicants to pilot a technology or innovation that has been utilized in other sectors in a transportation setting. For example, Missouri DOT (MoDOT) submitted an AID Demonstration application for the use of nanocoating technology, which forms a passive corrosion protection system that only requires two coats with the second coat being applied prior to drying, for highway bridges. Their existing painting process involved a 3-coat system requiring a lengthy closure time. Nanocoating has been used in the military, marine, and oil and gas industry for corrosion protection. MoDOT coordinated with the U.S. Army Corps of Engineers to address the proven requirement and demonstrate the technology was used in an operational environment. FHWA ultimately awarded the grant to MoDOT.

6.3.5 Innovation Portfolio

The final output of this sub-process is an innovation portfolio. As discussed in Chapter 5, the innovation portfolio is likely structured by short, medium and long term innovations, and by the type of innovation (sustaining, incremental, disruptive, and radical). This portfolio will be constrained by the agency budget, and will reflect the agency's strategies and goals. It will also be constrained by organisational capacity which must be taken into account for any project. The portfolio is key to prioritising development of innovations, and may be published as part of the agency's Innovation Strategy document.

6.4 DEVELOP SOLUTIONS

The third sub-process in the framework is to develop the innovations that have successfully undergone evaluation. Innovation projects from the portfolio are (often) subject to procurement and then development. Once in development, they will be subject to quality management and project management like any other project in the agency. Most agencies, especially those concerned with any form of public safety, have strict trialling policies and procedures which clearly set out the steps required to bring a technology or innovation into their operational environment. Lessons learned from trial will be fed back into the project plan and the innovation may be subject to refinement. There may be a re-assessment of the business case to establish whether costs are higher than anticipated, or whether anticipated benefits are not being realised. The earlier that any such issues are identified, the better so that development can cease and resources re-allocated. Any innovations that do pass all trial steps become 'solutions' which can then pass forward to the deployment process and becomes business as usual (BAU) within the organisation. This sub-process for Develop Solutions is summarised in Figure 13.

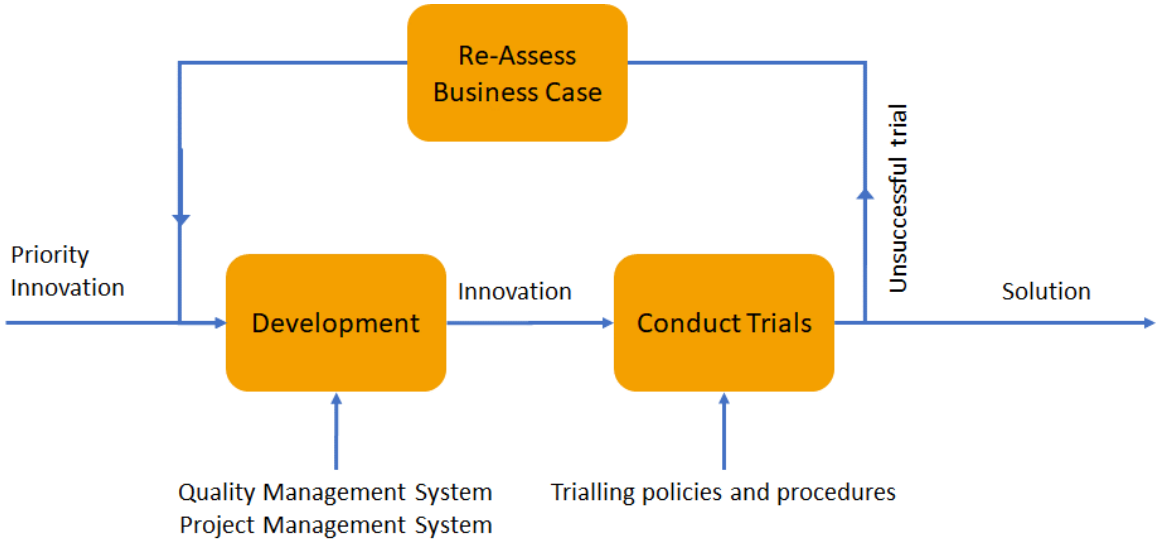

Figure 13. Develop Solutions

6.4.1 Development

Development of a project is project-specific, depending on the nature and type of the innovation. Most agencies will have detailed design guidelines and procedures for all types of project including for example planning, procurement, infrastructure design, construction, IT etc.). These will also include various stages and processes including proof of concept, conceptual design, preliminary and detailed design. All innovation projects would also be subject to project management in accordance with the agency's policies, procedures and systems.

The **SCU (Chile)** applies a structured and methodological approach that allows for adaptation to constant changes and addresses future challenges. Once the opportunity is identified and the innovation project evaluated and approved, an action plan is articulated and developed. During this phase, stakeholders are mapped out, and strategies to address the risks and challenges are defined. Involving diverse actors like the public sector, civil society, academia, and industries is important to ensure a comprehensive and sustainable perspective. It generates prototypes and pilots to test the proposed solutions. These pilots are evaluated, adjusted, and iterated upon as needed to replicate and expand the innovations. Constant feedback is essential to adapt solutions as challenges are encountered and lessons are learned. It is also noted that the methodology is based on adaptation and continuous improvement, and allows for the inclusion of project scalability. Starting with prototypes or pilots, the goal is to develop solutions that can be implemented on a larger scale, either regionally or nationally. This ensures that projects have a sustainability model in terms of both finances and governance, allowing for their continuity over time.

KEC (Korea) explicitly highlighted user-centric and rapid development methods as important for implementing innovations. User-centric methods are used for innovations that are designed to improve road users' convenience, and also for innovations in internal work processes. Rapid development methods are used for rapid changes to road infrastructure, such as innovations around safety or disaster resilience.

IMT (Mexico) tries to complete innovation projects over a relatively short time period, ranging from 6 months to 1 year on average. IMT does emphasize that all projects including innovation projects are subject to their standard production methodology and their quality management system.

UDOT mentioned Value Engineering as part of their innovation processes. Value engineering is a systematic and structured approach used to optimize the value of a product, project, or process while maintaining or improving its performance and quality. It involves analysing every element of the item under consideration to determine if any improvements can be made in terms of cost-effectiveness, efficiency, functionality, and overall value. The primary objective of value engineering is to identify areas where unnecessary costs can be reduced without sacrificing quality or functionality. Value engineering is quite project-specific and may be more suited to complex and expensive infrastructure projects.

6.4.2 Trialling Policies and Procedures

As highlighted above, many transport organisations have strict policies and procedures for trialling any innovations that relate to the transport infrastructure or services, road users, road construction workers or maintenance workers. These typically cover proofs of concept to ensure alignment with agency goals and objectives, feasibility design and sizing to ensure a concept is reviewed at the correct scale, detailed pilot design, implementation, and closeout review including dissemination of lessons learned and outlining of next steps for ideas.

Risk management and risk mitigation management also typically occur in parallel as an innovation goes through its trial process. **NH (UK)** publishes general guidelines for safety risk assessments (GG 104 Requirements for Safety Risk Assessment, 2018). These describe a process for risk assessment planning, categorisation of activity types, identification of affected populations, safety risk assessment scope, development of a safety risk baseline and safety objectives. Risk assessment planning and scoping includes identification of statutory and formal processes, and consideration of the applicability of current standards and guidance to the project being considered, the impact to the organisation, and the impact to stakeholders. The results of the risk assessment determine whether a safety control review group needs to be established to approve the assessment and to approve the safety review process for the project. Safety risk mitigations can also be proposed and implemented.

6.5 IMPLEMENT INNOVATIONS

Once a solution has been successfully tested and trialled, it is necessary to deploy it and eventually incorporate it into the agency's processes as 'business as usual'. Depending on the nature and scale of the innovation, this may require changes in regulations; changes in standards, guidelines and procedures; customer engagement; supply chain engagement; training; and dissemination. Many of these activities will have been considered during the course of development of the solution, but will now need to be formalised into an implementation plan for adoption and scaling up of the new innovation. Budget, organisational goals, and organisational capacity are the typical key constraints on the implementation plan. Change management is also an important part of the implementation plan, as the innovation potentially involves changes to working practices across the business. See Figure 14. Preparation of the implementation plan and actual implementation of the innovation should be supported by the agency's project management systems. Monitoring of benefits of the innovation are also important, these are considered as part of the support processes for innovation as described later in this chapter. At the end of the process, the innovation is deployed and monitored and eventually adopted as 'business as usual' (BAU).

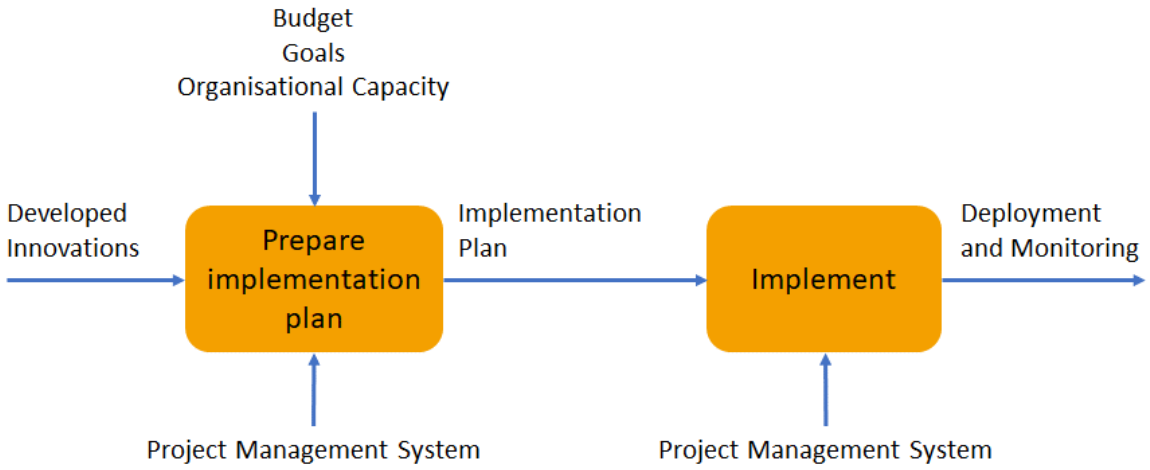

Figure 14. Implement Solutions

6.5.1 Prepare Implementation Plan

Implementation planning is key to any project, including for the deployment and scaling up of innovations. An implementation plan must identify the key activities, scheduling, resources, and include identification and mitigation of risks to ensure that the organisation's goals are met. It acts as the bridge between the innovation and the implementation.

6.5.2 Implement

Scaling up has been identified as a key issue by many of the case study organisations.

SCU (Chile) highlights that planning for scalability is an integral part of the early prototyping and piloting stages, hence preparation of the implementation plan can be based on a product or service that has been designed and developed for scalability from the outset. SCU deliberately solutions that can be implemented on a large scale, either regionally or nationally. Project are considered for sustainability in terms of both finance and governance, helping ensure their deployability over time.

As also noted above, **KEC (Korea)** reports efforts to develop ideas and implement them more quickly than others, particularly around safety related and disaster resilience innovations.

For innovations selected for inclusion in the **FHWA's** EDC program, FHWA deployment teams develop budgets and Implementation Plans based on the identified "market demand" from the States that occurs following the roll out of the program. These implementation plans include executing a variety of technical assistance activities (training, peer to peer learning, workshops, etc.) in a variety of formats (in-person, virtual, hybrid), along with development of technical matter (case studies, media, standards, specifications, etc.).

The FHWA's Accelerating Innovation unit also offers assistance through its STIC Incentive and Accelerated Innovation Deployment (AID) Demonstration programs to encourage and provide incentives for innovation deployment. The STIC Incentive program provides up to 100,000 US$ per year per STIC to help institutionalize innovations. The AID Demonstration discretionary grant program provides an incentive of up to $1 million to support the cost of deploying an innovation on any phase of a highway project. The program has historically made available up to 10 million US$ per year in incentive funds. These monies are ultimately disbursed to FHWA stakeholders

(typically State DOTs and local or tribal transportation agencies) for their direct action, with FHWA monitoring progress on these projects and products, and again sharing successes achieved with a wider audience.

ODOT (Oklahoma) also highlighted the risk of "falling back into old habits" during this scaling up process, and seeks to embrace change and adopt an attitude of continuous improvement to help reinforce ensure continued implementation of innovation projects. This is a particular challenge in Oklahoma because of the widely dispersed rural nature of the state and the distance between staff. Dissemination of information and continuous reinforcement within the organisation is seen as important to drive home the innovation message.

Thus some case study agencies have identified a major issue around scaling up and have tried to address it through various measures. However, further research into this is recommended to investigate ideas and provide additional guidance.

6.6 ORGANISATION SUB-PROCESSES

The Organisation sub-processes concern the organisational culture and internal and external collaboration. Chapter 4 Creating a Culture of Innovation showed how Human Resource Management processes can fundamentally affect the culture of innovation within an organisation, and how a well-designed human resource management system can help attract, nurture, and retain individuals with the distinct attributes required to drive innovation. Chapter 4 also described how there has been a gradual shift towards collaboration between transport agencies and their supply chains and wider industry, and described how the case study agencies processes help encourage such collaboration.

6.7 SUPPORT SUB-PROCESSES

Procurement and aspects of Human Resource Management considerations were also discussed in Chapter 4. This section wraps up the support processes by focusing on Dissemination about innovations, and on Measurements System as described in Chapter 5.

6.7.1 Dissemination

Dissemination in innovation is to ensure that the agency's values, strategies and goals, and its creativity in achieving them, are shared with a wide audience. Dissemination is important to gain support from stakeholders, to secure resources, to inspire adoption of recent innovations, and to enthuse others to innovate.

Dissemination can occur at all stages of the innovation process. It can apply during ideation, design, trialling or deployment. It can apply to any stakeholder, both internally within the organisation, and externally to the public, the supply chain, governing or regulatory authorities.

Theoretically, it may make sense for dissemination to be managed by a central service in an organisation. This could have significant advantages. Centralised dissemination makes it easier to have unified and consistent messaging and to ensure that any dissemination aligns with organisational values and goals. Also, for major innovations, a dissemination or communications plan will likely be needed to properly identify stakeholders and user groups in advance of forthcoming innovations or deployments. Centralised services often include in-house experts in

communications, marketing or public relations with specific skills and experience to ensure that correct messaging is applied in a timely manner. Often, engineers or other professionals do not have the skills or training or wherewithal to formulate and implement good dissemination and communications plans.

Some examples of best practice and even innovative ideas around dissemination identified in the case studies include:

- Some case study organisations put 'innovation and research' front and centre in their organisation's mission statements or objectives and in their website. Including 'innovation and research' up front in their website immediately informs the public and stakeholders about the agency's commitment to innovation, and helps build a culture of innovation within the organisation.
- **KEC (Korea)** publicises the impact of implemented innovations through newspapers, broadcasting, and even in expressway facilities such as rest areas, tollgates etc. Showing 'tax dollars' at work can help create a better relationship with the public or stakeholders served by the organisation.
- **IMT (Mexico)** encourages staff to publish technical and scientific articles in different national and international journals. If so published, these articles are stored in the IMT database and are available on the IMT publications website. IMT maintains a 'communications matrix' that establishes appropriate channels for publicising results of research and innovation project, both internally and externally.
- **IMT (Mexico)** also conducts weekly Transport Seminars to share innovations within IMT. Staff present results of their work, methodologies used, risks encountered, and their impact on the transport sector.
- **NH (UK)** uses personas in many of its external communications. Personas are fictional profiles of groups of similar people in a target audience. They can help organisations reach people on a more personal level while delivering the key messages. Personas can also be grouped into segments (e.g. less mobile, car reliant; young urban families; older less affluent) to help in identifying how an innovation might impact different groups in society.
- As mentioned above under scaling up, **ODOT (Oklahoma)** highlighted the risk of "falling back into old habits", and emphases the importance of dissemination of information and continuous reinforcement within the organisation as important to drive home the innovation message.
- **UDOT (Utah)** noted that public relations is important in garnering support from the press and elected officials. UDOT publishes an annual Innovation and Efficiency Report to demonstrate and evidence its innovations and savings. Even leaving a copy of the Annual Innovation and Efficiency Report on a coffee table in UDOT offices receptions can help generate a feel-good factor in the organisation and with any visitors. UDOT cites strong ties between their Innovation and Public Relations team as helping drive their innovation programs.
- **FHWA** identifies a major challenge in "selling" innovation implementation as a key business case for making change. It is recognised as important that innovation champions clearly and

convincingly describe the "why" behind an innovation than it is to focus solely on "what" the innovation is. It therefore champions a "story-telling approach", focusing on the facts supporting an innovation and the positive impacts that they have on travel times, resources and safety. Stories supporting these facts, ideally provided from peers for peers, serve to amplify the business case for potential new users of innovations. Of course, it is important that those claimed impacts can be substantiated, which leads onto the final section of this innovation process report on measuring innovations.

- **UNRA (Uganda)** recognises that knowledge management within the organisation is also key. It has identified knowledge as a strategic asset, to be explicitly managed by its new R&D Department, and for UNRA to be recognised as a learning organisation.

7. SELF-ASSESSMENT TOOLS

Self-assessment tools in innovation are used to evaluate the capabilities and abilities of organisations to develop and produce new ideas. While they focus on internal capabilities to identify areas for improvement, they may also involve comparison with standards and best performing institutions to make sound judgements.

Self-assessments enable transport agencies to also stay relevant and competitive. Transport agencies like many other institutions are faced with the constant need to evolve and adapt to the technological advancements and rapid developments. Through self-assessment, they are able to evaluate their response to changing market conditions and readiness to tap into emerging technologies to enable them to stay relevant, or become more relevant, to customer demands.

7.1 PURPOSE AND TYPE OF SELF-ASSESSMENT TOOLS

Self-assessment tools are useful in **identifying gaps and opportunities** to enhance an organisation's innovation capabilities. Tools are typically structured around evaluation of current practices, work culture and processes. These help to pinpoint areas that may require improvement and changes, or aspects of existing practices which need to be encouraged.

The process of assessing an organisation's innovation capabilities also requires the collection of data or information. This allows the organisation to have an objective understanding of its current situation to **make informed decisions**. This is especially useful in organisations where resources are constrained, yet there are a large number of projects that need prioritising. It enables institutions to efficiently allocate manpower, budgets, and technological investments towards innovation.

One of the decisions that may emanate from a self-assessment are the **transformation of the organisation's work culture**. Some tools have an explicit focus on culture. Through the assessment of various aspects of their work such as openness to new ideas, ease of collaboration both internally and externally, and their level of risk tolerance, it becomes easier to see if the organisation embodies an environment conducive to foster innovation and make necessary adjustments. Such tools can be opened up to the entire workforce, or a representative sample of the workforce, as time and resources permit, to gain feedback from employees.

Some self-assessment tools may on the other hand focus on **innovation as a process**. These tools are tailored so that innovation is placed at the centre of the assessment. This is achieved by providing clear methodologies and relevant assessment criteria to ensure that innovation is at the heart of the institution's goals and targets.

Tools are useful in **measuring progress** on the transport organisation's journey in terms of innovation over a period of time. By defining and measuring against Key Performance Indicators, they can provide a benchmark for assessments. Through the monitoring of progress, they enable the organisation to identify setbacks and re-strategize to achieve the set targets.

Tools can also be useful to **engage stakeholders** and solicit their feedback on the organisation's performance. Although, the idea of self-assessment is more of an introspection, road users, designers and other relevant stakeholders may be involved in the process. This gives external perspective of how innovative the institution is.

7.2 EXAMPLES OF SELF-ASSESSMENT TOOLS

National Cooperative Highway Research Program (NCHRP)

The National Cooperative Highway Research Program (2018) designed a self-assessment tool which helps Departments of Transportation make informed decisions about areas to prioritize to enhance innovation. This tool is designed to either help the agency to assess its readiness or to improve on-going efforts. It provides an opportunity for institutions who have already made progress to evaluate their innovation capabilities.

This assessment is conducted under five main building blocks: leadership, empowerment, recognition, communication, and measurement. These building blocks are structured under beginner tasks, intermediate tasks, and advanced tasks. The structure reflects the stage of innovation life cycle the institution may be in.

Through the establishment of appropriate **leadership**, it also becomes easier to manage and influence the organisation towards the achievement of innovation targets. Clear leadership helps to streamline innovations efforts with the institution's wider goals.

Two intermediate blocks identified for the assessment were **empowerment** and **recognition**. To enable employees to freely develop new ideas and receive feedback on it, there is the need to enhance how employees behave, approach problems, and find solutions. Again, it is important to institutionalize processes that highlight and promote employees who go above and beyond to enhance work processes and performance. Apart from the morale boost it provides to individuals and teams, it also encourages innovation among other employees and teams.

Communication is identified as a critical block. It underpins every aspect of innovation development within the institution. By facilitating the flow of information, it enables employees to understand the relevance of innovation efforts and the part they can play in achieving the institution's innovation goals.

At the advanced stages, the tool focuses on how innovation is **measured** and enhanced. Measuring innovation, as a critical block at this stage, ensures effective implementation of new ideas. There should therefore be structures in place to that test the efficiency of new ideas and provides useful feedback to either enhance the idea or project or inform future developments.

Railway Industry Association (RIA-UK)

The Railway Industry Association (RIA-UK) in 2022, launched an innovation self-assessment tool that enables railway organisations and individuals to assess their readiness to innovate using five indicators; that is; knowledge of the railway industry, knowledge of customers, knowledge of customer's acceptance of the process, knowledge of technology for innovation and knowledge of the institution capabilities. The outcome of the assessment is a spider diagram which juxtaposes the institutions current understanding of what is needed to innovate with what is currently in place. Based on the outcome of the assessment, they are able to provide relevant recommendations to help enhance innovation within the organisation. Figure 15 is a sample of the output of the assessment.

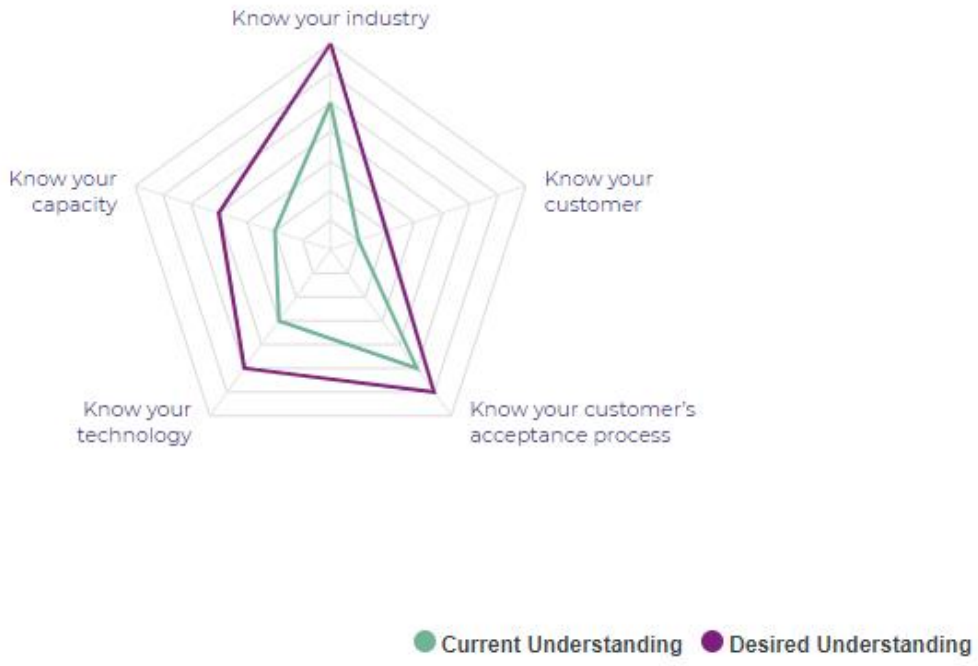

Figure 15. Sample Self-Assessment Tool Generated through RAI-UK

Oslo Manual

The Oslo Manual (OECD/Eurostat, 2018) provides guidance on measuring capabilities for innovation, although not specifically for transport organisations. It differs from the tools highlighted above in that, beyond the institutional framework, it considers both internal and external factors which influence innovation.

The internal enablers include **general resources** such as the firm's age, business assets and financial ownership; **management capabilities** such as organisational and managerial capabilities and their competitive strategy; **human resource** such composition of workforce by level, skill and educational attainment; and **technological capabilities** such as their technical expertise, design capabilities and capabilities to use emerging digital technologies and analytics.

External factors are usually out of the control of the organisation. Yet, they play a critical role in how innovative an institution can be. For instance, the **location of the institution** can influence their access to new and improved technologies, ideas, and experts. Similarly, government support programmes, existing public regulations and innovation infrastructure provided by the government could propel the institution's innovation capabilities.

The Observatory of Public Sector Innovation (OPSI) in Australia at one time contained a Public Sector Innovation Toolkit, and invited users either to complete a self-assessment using the toolkit, or to submit toolkits that they have used (Observatory of Public Sector Innovation, 2014). The toolkit appears to have been archived, but clearly embodies many of the concepts contained in this report, and would warrant further investigation.

7.3 KEY FEATURES OF TOOLS NEEDED FOR TRANSPORT AGENCIES

In essence, there are many aspects that may influence the structure of the innovation self-assessment. However, for transport institutions some of the key elements that need to be included should be:

- Leadership. The assessment tool needs to evaluate the role of leadership in driving initiatives in the organisation. Having innovation leaders as highlighted in previous sections, helps to stimulate innovation in an agency through the development of an innovation vision and strategy, establishment of chain of communicating innovation ideas and plans and prioritisation of innovation in resource allocation.
- Organisation's culture. Assessing the organisation's culture is also a necessary to determine how well it supports or encourages innovation. A strong innovation culture fosters creativity, risk-taking and the need to constantly improve. Here the tool seeks must establish employees understanding and level of commitment to the institution's innovation goals and targets. It also helps to establish the degree to which teams and department within the transport institution collaborate to enhance their innovation capabilities. For the culture of innovation to be nurtured, it is necessary to have clear programs and strategies that instil the desire to innovate in staff and encourage them to the urgency to rethink how things can be done more efficiently and productively.
- Human resource. The human resource is the main driver of innovation. It is important for the institution to assess the capabilities of the human resource in terms of their knowledge, skills and commitment. The human resource management of the institution should have in place a system that ensures that the staff are able to engage and promote the institution's innovation goals and targets.
- External collaboration. As indicated in the Open Innovations section, it is necessary for transport organisations to avoid 'innovating in isolation'. The right tool must help transport organisations to gauge their willingness and ability to collaborate with external institutions including start-up, research institutions and other relevant stakeholders.
- Technology. The impact of artificial intelligence, robotics, internet of things and other emerging technologies on innovation in transport organisation cannot be underscored. The assessment needs to take stock of the existing technologies (i.e., what is available internally as well as external technologies that are accessible to the institution).
- Finance. Budgetary allocations can indicate an institution's commitment to innovation. It is critical to assess the financial commitment of the institution when it comes to enhancing staff skills, developing technologies, and undertaking activities aimed at enhancing innovation.

ISO/TR 56004:2021 recognises that different industries and organisations may have different approaches to innovation, and that assessments need to be tailored to the organisation. It also may be that a combination of different tools may be needed to adequately assess an agency's culture and capability.

7.4 OUTCOME OF AN ASSESSMENT

Based on the assessment, the transport agency should be able to define its level of maturity. Different tools assess different aspects of innovation. Of the tools discussed in the previous section, the RIA-UK tool is to assess an organisation's readiness to innovate, while the NCHRP tool assesses both the readiness to innovate and the innovation performance.

We suggest an amalgamation of these different levels of assessment, and categorisation into three main stages - emerging, evolving, and mature. See Figure 16.

At the **Emerging stage**, the organisation does not have a consistent or structured approach to innovation. While there may be signs of individual innovation efforts, the organisation's innovation capabilities are often characterised by limited resource allocation (including time, human and financial) and inadequate integration of innovation into the organisations' strategic plans. The primary focus, at this stage, can be on building a basic innovation framework which will serve as the foundation for developing their innovation capabilities. This could include institutionalising innovation management (i.e., with clear leadership, goals, and strategies) and encouraging the culture of innovation among employees.

The **Evolving stage** is characterised by deliberate actions. Here, the organisation has a more proactive approach to managing innovation activities. It is characterised by structured human and financial resource allocation to innovation activities. However, innovation efforts and activities are limited by the lack of integration into core business functions. The focus at this stage can be on prioritising innovation and aligning it to the institution's strategic goals and targets.

Organisation at the **Mature stage** have well established innovation management systems which is embedded into their core functions and operations. Such institutions are often characterised by clear leadership within the industry and the development of new and relevant ideas. Although this is seen as the last stage, it is not an end. Institutions may be challenged by the need to maintain innovation culture among their changing employees and adapt to the ever-changing society to remain relevant.

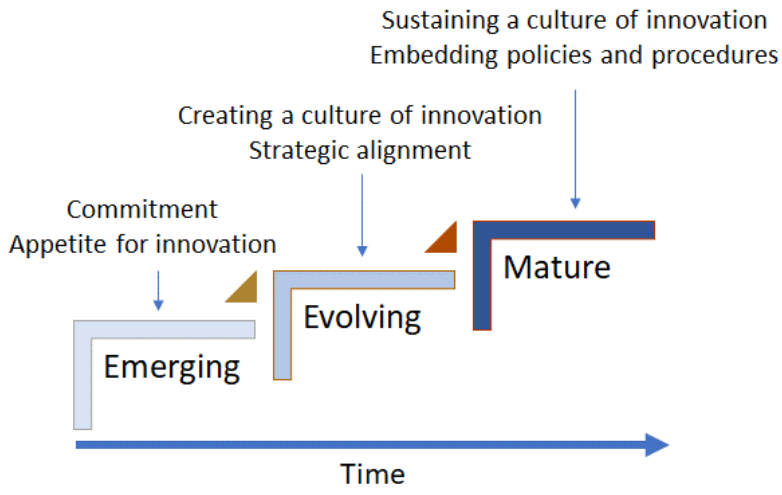

Figure 16. Innovation Maturity Stages

Figure 16 acknowledges that time alone is not the sole determinant for moving between the stages. It draws on established management frameworks, incorporating elements such as leadership commitment and appetite for innovation; creating a culture of innovation and strategic alignment; and sustaining a culture of innovation including embedding of policies and procedures.

Ultimately, transitioning from one stage to another and maintaining good innovation capabilities within the organisation requires regular assessment against key performance indicators to make informed adjustments. This is especially necessary as transport agencies are faced with increased competition, rapid technological advancement and the need to adapt to changing circumstances.

The self-assessment, of course, is one part of the cycle of continuous improvement. A self-assessment will provide insights into strengths and weakness, opportunities and threats. It is then up to the agency to follow up on that assessment by producing a plan for improvement of its innovation process, and gauge its progress against such a maturity model. This is elaborated upon in the recommendations in Chapter 8.

8. CONCLUSIONS AND RECOMMENDATIONS

This chapter contains key conclusions and recommendations synthesised from reviews of literature, case study responses, and selected presentations from agencies at the WRC Prague in 2023. It gives a snapshot of the state of the innovation process in different types of transport agency, providing an opportunity to consolidate and showcase some best practices.

8.1 KEY FINDINGS

1. Innovation as a Process

Viewing innovation as a process, rather than as something that 'just happens', has proved a transformative shift in many organisations. This view recognises innovation as a systematic, repeatable set of activities that have defined goals, that can be managed, measured, encouraged, and improved.

Standard process modeling tells us that processes have inputs and outputs, mechanisms and constraints. Viewing innovation as a process akin to that described in ISO 56000 focuses thinking on each of these areas. It identifies the flow of opportunities and ideas in an organisation, the evaluation of those ideas, development and deployment of those ideas as projects, and the value that they create. Viewing innovation as a process also focuses thinking on the policies and procedures necessary to improve innovation, recognises the innovation ecosystem within which the organisation operates, and identifies the people and the support services and activities needed to make it happen including, importantly, the budget.

2. Evolution Towards Open Innovation

There is a general consensus that there is an evolution towards open innovation. Transport organisations in the past have perhaps been quite prescriptive and highly technical in their specifications. They have gradually moved to a more Open Innovation approach, involving citizens, startups, digital technology companies. A relatively small number of our case study agencies mention their aspirations towards and open innovation approach, and although some of them implement some of the concepts of open innovation, there are still opportunities to move towards a fully open approach, especially through greater involvement of the supply chain at earlier stages in projects.

3. Organisational Structure Impacts Innovation

Organisational studies across different industries are clear in that adopting flatter, decentralised organisational structures, where decision making power is found closer to those staff who carry out those decisions, is more likely to lead to successful innovation outcomes. Related to this, establishing clear and open communication between decision making staff and staff who action those decisions will also likely lead to better innovation outcomes. An organisational unit dedicated to innovation, and facilitating innovation in other parts of the organisation, appears to be instrumental to the success of innovation in the organisation. Several of the case study agencies described in this report have established such offices in the recent past, or are in the process of establishing such offices, as key way of driving innovation forward.

4. Human Resource Management is Fundamental to Nearly All Aspects of Innovation

Human resources are often cited as the most important asset in an organisation, and it follows that giving people the time and resources to do their job, and the encouragement to identify improvements, are important to innovation. Quite apart from the often quoted aspects of culture of innovation, there are key elements of human resource management that can be highlighted and focused on. These HR aspects include diversity of workforce and teams, staff recruitment, staff retention, staff appraisals, awards and recognition, implementation of integrated knowledge management systems and project management systems which help rather than hinder innovation. Some of these aspects of HR management may be referred to as 'talent management' in some countries or agencies, although talent management can tend to focus on key individuals, whereas some of the more general HR concepts should apply across all staff in the organisation.

5. Measuring and Communicating the Value of Innovations is Important for Funding

It should always be borne in mind that many innovation projects are specifically designed to save money in the long term. So although innovation projects cost money, a well-run innovation process can be seen to produce significant savings in both the short and long terms not only for the transport agency but for wider society. This is particularly important in an environment where budgets are being cut and there is an ever-greater need for improved productivity. Communicating information about innovations and their impacts is thus seen as important in attracting funding.

6. Investigating Alternative Sources or Methods of Funding

There are multiple ways in which innovation can be funded. For example there has been recent interest around value capture financing, green financing, blockchain and digital tokens for road usage, and public-private innovations which can bring fresh capital and innovation to projects. Embedding innovation funding into capital projects and maintenance budgets can also to help drive efficiencies or allow adoption of state-of-the-art equipment, systems or processes.

7. Engagement with National Innovation Ecosystem Services and Expertise is Important

Proactive engagement between transport organisations and their national innovation ecosystems are important. National systems can provide expertise and experience in all aspects of the innovation process – including creating collaboration networks, identification of opportunities, running competitions, evaluation methods, provision of innovation services etc. These can all help kick-start or improve innovation within an agency. Transport organisations should not wait to be contacted by their national innovation agencies, they should be proactive and make that initial contact to determine what resources or services may be available.

8. Embrace and Change the Language around "Failure"

The language around 'failure' is important. A clear strategy to embrace 'failure', or to reframe the language around outcomes of innovation projects, can help to foster a culture of innovation, and encourage employees to take on challenges and experiment with new ideas. Also, reframing the language will help cast the agencies in a different light when reporting on innovation activities to oversight organisations or to the wider public.

9. Self-Assessment Tools are Important in Creating Roadmaps to Improve Innovation

There are many self-assessment tools available that can measure different aspects of an organisation's capability to innovate. Some of these have been specifically designed for transport agencies. These can be a valuable tool as part of an initial assessment or as part of a cycle of continuous improvement, and can be used to develop roadmaps for improvement.

10. Innovation Management Systems are Available and Should be Considered

There are also many innovation management systems available on the market. Although only one case study organisation admitted to using an off-the-shelf system, further investigation and research into the applicability of these tools for different types and size of transport organisation would be useful.

8.2 KEY CHALLENGES

1. Funding for Innovation

Funding is always an issue for any activity. Some of the case study organisations in this report suggest innovative ways of addressing this problem. The organisational mandate or legal setup can obviously constrain some of these methods, but some agencies are able to generate their own resources through various means. Other agencies are looking to embed more innovations in regular projects and maintenance budgets so that it does not come out of an explicit innovation fund. Good measurement of the dissemination of the impact of innovations is also cited as an important tool to justify future funding in innovation. This report also lists some innovative funding methods being actively considered in the roads sector such as value capture financing, green financing, and blockchain transactions for road usage which could generate additional funding for innovation as well as regular operations.

2. Regulatory Barriers

Several of the case study agencies, including the SCU (Chile), DGC/MITMA (Spain) and Netivei (Israel) explicitly identified regulatory barriers as a key challenge to innovation. Such barriers may present themselves as strict requirements for adherence to standards (such as in road construction or maintenance), or liability rules surrounding accidents involving autonomous vehicles or autonomous plant. Key to addressing such barriers is to identify them early in a risk assessment framework, and encourage high-level review and analysis of the exact nature of the regulation and if and how it may be modified. Some types of regulation may require separate research and/or wider stakeholder engagement and a separate roadmap or implementation plan focusing on the regulations themselves.

3. Scaling Up

One of the biggest problems identified by agencies is scaling up of innovative solutions. This report contains some suggestions on how this problem can be addressed, for example by explicitly considering options for scaling up during the evaluation and design phases of innovations. This is also an area in which dedicated innovation specialists within an organisation, or in the private sector, or in the national ecosystem can provide expert guidance. However, further research into this is recommended to investigate ideas and provide additional ideas.

4. Tracking and Measuring Incremental Innovations at Local Levels in Large Organisations

Tracking and measuring incremental innovations at local levels in large organisations can present some challenges and opportunities. While many formal efforts introduced centrally may be well-documented, other incremental innovations may be implemented at local levels without visibility at the central level. Also, incremental innovations may be quite hard to measure anyway because it may be difficult to identify their individual impact in the overall process.

5. Resistance to New Technology

Resistance to new technology has been cited as a key challenge. Resistance can stem from a variety of sources, such as fear of change, uncertainty, or a preference for the status quo. When employees or stakeholders resist new technology, it not only slows down the adoption process but also stifles creativity. Agencies have proposed greater emphasis on change management, and on improving the innovation culture, but it still seems to be an intractable problem.

6. Too Busy to Innovate

Being “too busy to innovate” is commonly cited as a challenge. Although it can be a way of resisting technology, it may in fact be true. Innovative ways of addressing such a barrier, for example through a more emphasis on change management, providing more support to the workforce, and providing fit-for-purpose tools, may help reduce this challenge.

8.3 RECOMMENDATIONS FOR ROAD AND TRANSPORT AGENCIES

This section contains recommendations for improving innovation in road and transport agencies. These recommendations hold for any agency, regardless of size, budget, location, or where it is on its journey towards improving innovation. The first recommendation, to conduct a self-assessment, will help the agency to identify its gaps and highlight areas for improvement, and produce a prioritised action plan which should also consider the other recommendations given below.

R1. Conduct Self-Assessment

This report has identified several self-assessment tools that can measure different aspects of an organisation’s capability to innovate. Some of these tools have been specifically designed for transport organisations. These can be a valuable tool as part of an initial assessment or as part of a cycle of continuous improvement, and so can be applied to any agency at any stage in its journey to improving innovation. It can be used to assess an agency’s maturity against a maturity model as discussed in Chapter 7.

However, there are different tools for different purposes: for example, some tools focus on the organisations innovation culture and may be opened up to employees to obtain their feedback, others focus on the innovation processes, while others may include surveys of the supply chain or external stakeholders to gauge their perspective. We recommend choosing an appropriate self-assessment tool or tools and applying them to help identify a transport organisation’s current status, and help articulate its goals and develop action plans for continuous improvement in its innovation process. The national innovation agency in each country may be able to advise on tailored tools for that country or region.

R2. Consider Innovation as a Process

Consider innovation as a process which needs to be managed in the same way as other processes, with inputs, outputs, policies, procedures, and strong leadership and management. Viewing innovation as a process gives clear direction and accountability, a focus on measurable outcomes, and a mindset of continuous improvement. There are several authoritative process models available as described in this report that can act as a blueprint for any agency to devise its own internal processes commensurate with its capacity and budget and timeframe. Not all parts of the process need to be implemented at once, a roadmap to develop or improve innovation can be devised and followed over a number of years as the organisation matures.

R3. Consider a Separate Business Unit or Team to Drive Innovation

Consider a separate business unit to drive innovation. Such a unit can be considered as the owner of the innovation process, it can create and manage an innovation portfolio to help ensure that the business strategy can be achieved through innovation, and provide a clear structure and support to the rest of the organisation to identify, evaluate, develop and deploy innovations.

if a full organisational unit is not feasible within available resources, or if an agency is in the early stages of implementation, then a small team or project management office should be considered.

Care needs to be taken, though, that that innovation should not be considered as being in the domain of only one business unit, and it is encouraged across the whole agency.

R4. Consider an Open Innovation Approach

Transport agencies appear to be evolving towards a more open approach, where citizens, startups, and technology companies are becoming more involved in the innovation process, and where the supply chain is being actively encouraged to participate through innovative tendering mechanisms and alternative methods of collaboration. Consider an explicit commitment to open innovation, and all that that entails, to encourage greater innovation both internally and externally.

R5. Review Funding Mechanisms for Innovation

This report has identified some different ways in which innovation is funded, or is being considered for funding. Also multiple fund sources may be available elsewhere in the national or regional ecosystems, and the transport administration can look to work with other government agencies to fund innovative activities such as challenge tenders or hackathons to increase private sector participation and to generate additional innovative ideas. Transport agencies should review options or alternative ways of funding innovations, for internal as well as external innovations.

R6. Explore Ways to Integrate Innovation into Human Resource Policies and Procedures

As seen in this report, human resource management is fundamental to the culture of innovation within an organisation. Transport agencies should review their current HR policies and procedures to identify opportunities for improving those, specifically in the areas of diversity of workforce and teams, staff recruitment, staff evaluation, staff retention, incentives, identification of training programmes on innovation and innovation processes, and opportunities for mentoring.

Change management (preparing organisations for change as a result of innovation) has also been cited as important in innovation management, so specific training for change management should also be considered as part of general training for staff involved in innovation management. Several

of the case study agencies also mention agile project management as important in managing innovation projects, so agile methods could be considered for incorporation as part of a standard training programme for both project management and technical staff. In short, there are likely to be many opportunities from an HR perspective that could contribute to improving the culture and processes around innovation.

R7. Engage Proactively with National Innovation Ecosystems

Transport agencies should actively engage with the national innovation ecosystem, to understand what government funding may be available, investigate and discuss different mechanisms of procurement, avail of innovation training and expertise, build innovation partnerships and networking, and understand how government uses metrics to evaluate effectiveness of their policies. Also, as mentioned above, transport agencies may work with other agencies to encourage and fund innovative procurement activities such as challenge tenders or hackathons. Such engagement with the national innovation ecosystem will also help identify innovation in other industries or sectors nationally which may be evaluated for potential implementation in the transport agency.

R8. Explore Strategies to Better Manage Risk Associated with Innovation

The case studies have shown a significant variation in the way in which agencies evaluate risk and how risks are managed. A structured approach to risk management allows agencies to identify, assess and mitigate potential risks, and use the results of those assessments when creating an innovation portfolio. A more formal process will allow better or earlier identification of challenges, and reduce the likelihood of expensive failures. It may also help improve the culture of innovation in the agency by giving a clear statement of the risks and help assure that risks are managed as part of an overall portfolio. Transport agencies should review their risk management processes to determine if risk can be better managed throughout the innovation process.

R9. Seek Strategies to Objectively Assess Maturity and Readiness of Innovations.

Technology Readiness Levels (TRLs) are important for innovation in several ways. They provide a systematic way to assess the maturity of a technology, helping agencies understand the risks and potential benefits of adopting or developing a particular innovation. However, TRLs can be subjective, and are often the opinion of the supplier of the technology. Transport agencies should formulate their own TRLs if possible, and apply objective analysis, not simply accept the supplier view. Clearer and more objective assessment of current TRLs should achieve better innovation outcomes.

8.4 RECOMMENDATIONS FOR PIARC

This section contains recommendations for PIARC. Many of these relate to assisting road and transport agencies implement the recommendations from the previous section. Also, in the 2024 – 2027 Cycle, Technical Committee 1.1 will be examining issues and challenges around designing and creating the Transport Agency of the Future. Many of the experiences, findings and recommendations in this report, around creating an environment that encourages and supports collaboration, creative thinking, and the development of new ideas, products, processes and services, will be key to building that future, and so should be considered in relation to that future work.

R10. Encourage Road and Transport Agencies to Conduct Self-Assessments

This report has identified some self-assessment tools that can measure different aspects of an agency's capability to innovate. Some of these tools have been specifically designed for transport organisations. These can be a valuable part of an initial assessment or as part of a cycle of continuous improvement. However, there are a range of different types of tool available, for example focusing on the organisational culture from the employee perspective, or innovation processes, or collaboration from the external stakeholder perspective. We recommend that PIARC identify, develop, modify and/or promote a range of appropriate self-assessment tool or tools which can be used to help identify a transport agency's organisational culture and processes, to help articulate transport agency goals and develop indicators and action plans for continuous improvement in their innovation process. This will encourage agencies to identify gaps, highlight areas for improvement, and produce a prioritised action plan which should also consider all other recommendations R1 – R9 given for roads agencies above.

R11. Encourage Multilateral Development Banks to Assist with Developing National Innovation Ecosystems where possible, and Encourage Transport Agencies to Participate in their Development

We recommend that PIARC encourage multilateral development banks to assist with developing national innovation ecosystems, and that transport agencies be a key part of any such ecosystem development. Supporting development or improvement of national innovation ecosystems would have a knock-on effect on all innovation within that ecosystem, not only for transport but for other sectors.

R12. Encourage Engagement between Transport Agencies and their National Innovation Agencies

Transport agencies should actively engage with their national innovation ecosystem for the multitude of reasons mentioned above (including funding, access to resources, access to expertise, improved networking). In some countries, however, the national innovation ecosystem may not be well-established or mature, and/or transport may not be high on the agenda for government-led innovation. Where possible, PIARC should encourage engagement between the transport agencies and their national innovation agencies.

R13. Encourage International Collaborations on Innovation

This report has shown some examples of international collaboration in innovation not only in transport, but in general support to the innovation ecosystem in a country. Where such international collaborations exist in the setup and development of a national ecosystem, PIARC should encourage engagement between that ecosystem and the transport sector in the country.

R14. Encourage Engagement with Local Transport Authorities

In most countries, less than 5% of the road network is managed by the national roads agency. The other 95% of roads are run by local or sub-national authorities. In many cases, those local authorities have additional challenges to innovation. They are typically under greater financial pressure than their national counterparts, have greater staff constraints, and have fewer opportunities for collaboration with their peers.

A recent project in UK produced a roadmap to help Local Authorities become 'digitally fit for purpose' (Innovate UK, et al., 2022). The roadmap produced a vision for local authorities, covering

skills, strategy, technology, budget and data, and produced a common framework to work towards. It also produced an action plan broken down into national government actions, local authority actions and industry actions, recognizing the need for greater collaboration to avoid a patchwork of differing requirements and solutions emerging.

Also, the Local Council Roads Innovation Group (LCRIG) in UK has been established as a Community Interest Company (CIC) which means it can operate like any other limited company and can procure goods and services, lease offices and apply for government funding. It has recently set up an Innovation Procurement System (IPS) to provide local authorities with flexible tools for delivery of projects. The IPS is designed to remove barriers to innovation and to keep pace with changes in the market, and allows members to access innovation at scale and at a lower cost than other routes to market. Its first category is around innovations for highway surface treatments, which covers innovative ways to maintain and extend the life of carriageways, cycleways and footways. Thus, there may be innovative ways of increasing collaboration and reducing costs for local authorities.

PIARC should encourage national transport agencies to work with local authority counterparts on various aspects of innovation.

R15. Further Develop the Innovation Process Model for Transport Organisations

The process model developed in this report has been a useful starting point for discussion of the innovation process. We recommend further development or refinement of this process model with additional examples to provide guidance to transport agencies that are considering implementing an innovation process.

APPENDIX A. REFERENCES

Bibliography

Banathy, B. H. (1997). *Designing Social Systems in a Changing World.* New York: Springer.

CapGemini Consulting. (2012). *Innovation in Procurement.* Retrieved from CapGemini: https://www.capgemini.com/wp-content/uploads/2017/07/Innovation_in_Procurement.pdf

Carbone et al. (2012). Open Innovation in an Enterprise 3.0 framework: Three case studies. *Science Direct*.

CEDR. (2017). *Funding formulas for roads: Inventory and assessment.*

Chesbrough, H. W. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology.* Harvard Business Press.

Ciera, Xavie, Jaime Frias, Justin Hill, Yanchao Li. (2020). *A Practitioner's Guide to Innovation Policy. Instruments to Build Firm Capabilities and Accelerate Technological Catch-Up in Developing Countries.*

Connected Places Catapult. (2019, December). *HIGHWAYS ENGLAND HACKATHON LOOKS TO DIGITAL TRANSFORMATION OF ENGLAND'S ROADS*. Retrieved from Connected Places Catapult: https://cp.catapult.org.uk/news/cpc-hackathon-mobility-innovation-for-uk-road-network/

Cosh, A., Fu, X., & Hughes, A. (2012). Organization structure and innovation performance in different environment. *Small Business Economics* .

Dalander, & Gann. (2010). How Open is Innovation? *Research Policy*.

Design Council. (2005). *Double Diamond Framework for Innovation.*

Design Council. (2023). *Framework for Innovation*. Retrieved October 18, 2023, from Design Council: https://www.designcouncil.org.uk/our-resources/framework-for-innovation/

Eriksson, P. (2008). Procurement Effects on Cooperation in Client-Contractor Relationships. *Journal of Construction Engineering and Management*, 103-111.

Gaspary, E., Moura, G. L., & Wegner, D. (2018). How does the organisational structure influence a work environment for innovation? *International Journal of Entrepreneurship and Innovation Management*.

Government of Mexico. (2023, April). *Guidelines for the Technological Roadmap of Land Transport in Mexico, Vision 2021-2050*. Retrieved from https://www.gob.mx/sct/documentos/lineamientos-para-el-mapa-de-ruta-tecnologica-del-transporte-terrestre-en-mexico-vision-2021-2050

Huizingh, E. (2010). Open Innovation: State of the art and future perspectives.

IMF. (2023, April). *World Economic Outlook database: April 2023*. Retrieved from International Monetary Fund: https://www.imf.org/en/Publications/WEO/weo-database/2023/April/download-entire-database

Innovate UK, ADEPT, Jacobs, Ordnance Survey, Ringway, TRL, . . . VINCI. (2022). *Digital Local Roads.*

International Standards Organization. (2020). *ISO 56000: Innovation Management.*

International Transport Forum. (2019). *Transport Innovations from the Global South. Case Studies, Insights, Recommendations.*

Kennedy, R. (2020). *Strategic Management.* Retrieved from https://doi.org/10.21061/strategicmanagement CC BY NC-SA 3.0

Kotter, J. (2022). 8 Steps to Accelerate Change in your Organization.

Lenderink, B., Boes, J., Halman, J. I., Voordjik, H., & Doree, A. G. (2022). The development of a typology and guideline for selecting innovation-encouraging procurement strategies in civil engineering. *Innovation: The European Journal of Social Science Research*.

Lopes, A. P., & Monterio de Carvalho. (2018). Evolution of the open innovation paradigm: Towards a contingent conceptual model. *Science Direct*.

McKinsey. (2012, September). *Making innovation structures work*. Retrieved from McKinsey & Company: https://www.mckinsey.com/capabilities/strategy-and-corporate-finance/our-insights/making-innovation-structures-work-mckinsey-global-survey-results

Ministry of Science & Technology, G. o. (2020). *Science, Technology, and Innovation Policy (STIP).*

National Academies Press. (2018). *Guide to Creating and Sustaining a Culture of Innovation for Departments of Transportation.*

National Endowment for Science, T. a. (2009). *How to enhance working in employees and organisations. Research Report.*

National Highways. (2018). *GG 104 Requirements for Safety Risk Assessment.*

National Highways. (2023, September). *Connected and autonomous plant to 2035*. Retrieved from National Highways: https://nationalhighways.co.uk/our-work/innovation-and-research/connected-and-autonomous-plant-to-2035/

NESTA. (2009). *National Endowment for Science, Technology and the Arts. Everyday innovation. How to enhance working in employees and organisations. Research Report.*

Observatory of Public Sector Innovation. (2014, October). *Public Sector Innovation Toolkit*. Retrieved from Public Sector Innovation Toolkit: https://oecd-opsi.org/toolkits/public-sector-innovation-toolkit/

OECD/Eurostat. (2018). *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition, the Measurement of Scientific, Technological and Innovation Activities, OECD.*

Open Data Network. (2023, September 13th). Retrieved from Open Data Network: https://www.opendatanetwork.com/entity/0400000US49/Utah/economy.gdp.per_capita_gdp?year=2018

PIARC. (2022). *Best practices in funding and financing of road infrastructure.*

PIARC. (2023). *The Role of Transport Agencies in Shaping Disruptive Technologies and Service Models.*

Sinek. (2009). *Start with Why.*

Statistica. (2022). *Real per capita gross domestic product of the United States in 2022, by state*. Retrieved from Statistica: https://www.statista.com/statistics/248063/per-capita-us-real-gross-domestic-product-gdp-by-state/

Supply Chain Sustainability School. (2023, October). *Supply Chain Sustainability School*. Retrieved from https://www.supplychainschool.co.uk/about/what-is-the-school/

The Funnel Magazine. (2020). Israel's Corporate Innovation Magazine. (Winter 2020). Israel. Retrieved from https://issuu.com/ducoinnovation/docs/magazine_winter_web

Transport Infrastructure Ireland. (2020). *Guidelines for the Implementation of Innovation.*

Treasury, U. (2022). *The Green Book.*

TRL. (2020). *Connected and Autonomous Plant - Roadmap to 2035.* Retrieved from https://trl.co.uk/uploads/trl/documents/PPR955-CAP_Roadmap_1.pdf

UDOT. (2023). *Materials Innovations.* Retrieved from https://docs.google.com/presentation/d/e/2PACX-1vQBOtP-lmAz3pEJRn85_4q-S7xB_NjBNUQ_DNLMoNfMSN6WyILCqNalaX8Nla-XiNcD9a1lSHJo83m0/pub?start=true&loop=true&delayms=3000&slide=id.g1864f8659b6_0_22

UK Government. (2023, September). *Futures, Foresight and Emerging Technologies*. Retrieved from https://www.gov.uk/government/groups/futures-and-foresight

World Intellectual Property Organization (WIPO). (2022). *Global Innovation Index 2022: What is the future of innovation-driven growth?*

APPENDIX B. QUESTIONNAIRE

The following questionnaire was sent to all case study agencies, and completed by relevant personnel in those agencies. Appendix C contains a summary of the responses from those agencies.

This questionnaire is designed to identify key concepts and best practices employed by your organisation to cultivate, embrace, and sustain innovation.

Innovation can be defined as referring to the process of creating and implementing new or significantly improved ideas, products, services, processes, or business models that bring about positive change and deliver value. It involves the application of creativity, knowledge, and resources to address challenges, seize opportunities, and meet evolving needs.

A culture of innovation is not limited to specific roles or departments within an organisation but permeates across all levels and functions. It encourages individuals to think creatively, challenge the status quo, and contribute to the organisation's overall innovation efforts. How do you foster and support an environment which encourages the generation, exploration, and implementation of new ideas or processes or services? It is characterized by a set of shared values, attitudes, behaviors, and practices that encourage and reward innovation throughout the organization. It is about creating an environment where good ideas and new ways to solve challenges—on a large or small scale—are encouraged. Resources are allocated to support new initiatives, instead of people having to work around the system to try new things. Failure is tolerated, rather than punished.

1. Introductory

This section helps the reader to have some context of the information you are providing.

Name of organisation:	
Country or region:	
Spatial level of jurisdiction (e.g. national, regional, city):	
Primary functions under jurisdiction:	
Approximate number of employees in organisation:	
Length of road network under jurisdiction (e.g. total kilometers, number of bridges):	
Annual budget (US $):	
Annual capital expenditure (US $):	

2. Overall approach to innovation in your organisation

This section is intended to understand how your organisation sees its role in the context of innovation. What are your drivers for innovation? What is your approach to innovation, for example, is it top-down or bottom up? Do you have explicit strategies or policies to encourage innovation, both for major strategic innovations and for smaller everyday innovations? What is the balance between strategic innovations and everyday or incremental innovations?

3. How do you encourage a culture of innovation within your organisation?

Here we are seeking to understand how you encourage a culture of innovation ***within your organisation****. For example, do you have processes or procedures, or can you elaborate on, aspects such as the following – please provide examples or details as appropriate:*

- *Do you have a director or senior manager responsible for innovation?*
- *Do you have an ideas programme or equivalent that explicitly asks staff for suggestions for improvement? Is it formal, or informal?*
- *Do you have a mentoring programme?*
- *Do you have an incentives or a rewards or recognition programme? How do you deal with failed innovations?*
- *How do you consider innovation in the key stages of the recruitment process, including job descriptions, screening, interviews and final selection?*
- *Do you include innovation as part of your employee evaluations?*
- *How do you train and motivate your workforce to handle rapid or disruptive innovation?*
- *Others?*

4. How do you encourage a culture of innovation in your partner organisations or supply chain?

Here we are seeking to understand how you encourage a culture of innovation ***in your partners or supply chain****. Please elaborate on aspects such as the following:*

- *How do you create and support a culture of innovation in your partners and stakeholders?*
- *Do you consider innovation as one of the assessment criteria in your selection of suppliers or partners? If so, how?*
- *Do you organise or participate in innovation workshops or conferences?*
- *Do you organise or participate in innovation competitions?*
- *Others?*

5. Identifying and evaluating innovations in your organisation

Here we are seeking to understand how you identify and evaluate innovations. In responding, we ask you to consider the following questions. You are not expected to answer all these questions, just use them as a prompt for what information you might include here. If there are related documents in the public domain, please reference them here.

- *Do you attempt to anticipate future trends and developments to help identify opportunities for innovation?*
- *How do you identify or detect innovations that are happening in your organisation?*
- *How do you evaluate the risks when evaluating a particular innovation? Do you consider different types of risk? For example, regulatory, reputational, political?*
- *How do you assess the benefits and value for money of new ideas for innovation?*
- *Who is involved in the evaluation process? Is it senior management only, or are staff empowered to implement innovations without senior management approval?*

6. Implementing innovations

Here we are seeking to understand how you implement innovations in your organisation. In responding, we ask you to consider the following questions. You are not expected to answer all these questions, just use them as a prompt for what information you might include here.

- *How is innovation funded and budgeted for?*
- *Do you require or develop proofs of concept for some innovations?*
- *Do you require or develop minimum viable products for some innovations?*
- *Do you use any particular methodologies for developing ideas or solutions, such as a user-centric approach, or rapid development methodology?*

7. Managing and monitoring innovations

*Here we are seeking to understand how **you manage and monitor innovations** in your organisation. In responding, we ask you to consider the following questions. You are not expected to answer all these questions, just use them as a prompt for what information you might include here.*

- *How do you measure the success of innovations? What metrics do you use?*
- *How do you record lessons learned if implementation does not meet expectations?*
- *How do you institutionalise your innovations?*
- *Do you have any methods or systems for knowledge management?*
- *How does your organization promote/demonstrate the impact of implementing innovations internally, to elected officials, to the general public, etc.*

8. Challenges and opportunities for innovation:

*Here we are seeking to understand **challenges and opportunities** for innovation. In responding, we ask you to consider the following questions. You are not expected to answer all these questions, just use them as a prompt for what information you might include here.*

- *What are the key barriers and challenges to innovation in your organisation, and how have you responded to them?*
- *How do you liaise with, influence and benefit from other national and international bodies as regards innovation policies? This might include national "innovation agencies", innovation financial support mechanisms, regional calls for projects etc.*
- *What processes, concepts and approaches to innovation from other industries might be applicable to roads and transport organisations?*

APPENDIX C. CASE STUDIES

CHILE - SMART CITIES UNIT OF MINISTRY OF TRANSPORT AND TELECOMMUNICATIONS (SCU)

Introduction

The Smart Cities Unit (SCU) of the Ministry of Transportation and Telecommunications has a wide range of responsibilities including road maintenance operation; planning; and regulation. They manage 82,000 km of roads, whose construction ranges from sealed all weather pavements to gravel and unpaved roads. The SCU is a multidisciplinary team at a central level within the Ministry that coordinates nationwide technology prospecting projects and initiatives.

Approach to innovation

The SCU has successfully driven innovation projects since its inception in 2011. Their distinctive bottom-up approach, centered on active citizen involvement, has been pivotal to their success. By actively engaging with the public, they have harnessed feedback to create impactful solutions for urban mobility, utilizing innovative methodologies and advanced technology tools. Through sensorization, big data analysis, digital platforms, and mobile applications, they have revolutionized urban mobility, placing citizens' experiences at the forefront. This approach has not only fostered a culture of innovation within and beyond the institution but also established the SCU as a model of innovation in the public sector at the national and regional levels. They've proven that involving citizens in the planning and design of mobility solutions can bring transformative results.

Managing a culture of innovation within the organisation

The SCU fosters an innovative culture through several strategies: (i) By defining smart cities as technology-driven and people-focused, (ii) emphasizing citizen involvement, (iii) integrating mobility as a core element, (iv) adopting a forward-thinking mindset, (v) fostering collaboration, (vi) embracing failure as a learning opportunity, and (vii) providing resources and training. These approaches create an environment where creativity and disruptive thinking are encouraged, leading to solutions that improve urban life and promote sustainable city development.

Encouraging innovation in partner organisations or supply chain

They instil an innovation culture in affiliated organisations through (i) emphasis on social innovation that addresses societal issues, (ii) active community involvement in all project stages, (iii) proactive exploration of emerging technologies, (iv) promoting collaboration and co-creation among various stakeholders, (v) creating spaces for collaboration, (vi) forming a public-private collaborator network, (vii) recognizing academia's role, and (vii) encouraging organisational adaptability. These collectively foster innovation in urban mobility, aiming for comprehensive and sustainable solutions that improve people's lives.

Identifying and evaluating innovations

The SCU recognises that in a rapidly changing urban landscape, particularly in the dynamic field of mobility, the adoption of agile methodologies and adaptable approaches is crucial for addressing emerging challenges and scenarios. The SCU’s working model consists of three phases: exploration, design, and implementation. The exploration phase involves identifying opportunities and challenges, often in collaboration with international partners and fund-seeking efforts. This approach incorporates foresight and continuous improvement methodologies, starting with needs identification and progressing through research and idea testing, often utilizing pilot projects and

prototypes for validation. This iterative feedback-driven process also allows for scalability, beginning with prototypes and later expanding to regional or national levels while ensuring financial and governance sustainability for projects.

Implementing innovations

To elaborate on the three-stage process to implementing innovations in urban mobility described above: (1) Exploration, where opportunities and mobility challenges are identified with the aid of international cooperation and funding; (2) Design, where action plans are developed with input from diverse stakeholders; (3) Implementation, involving pilot projects and prototypes to test solutions iteratively. This adaptable approach allows for scalability and long-term sustainability, ensuring that innovations can address future challenges and positively impact smart cities.

Managing and monitoring innovations

As an innovation-focused unit, the SCU's work progresses through multiple stages, with a strong emphasis on driving significant advancements. After conducting and testing a pilot, they conduct a careful evaluation of its outcomes, particularly focusing on the benefits for users. If results prove positive, they move forward to institutionalize the solution, ensuring its adoption and compliance with specific requirements. When dealing with emerging services or technologies, their process involves formalizing these advances for integration into contractual foundations, facilitating efficient government procurement of these technologies. A critical component of their approach is the comprehensive documentation of all pilots and prototypes through a systematic record, serving as a valuable repository of insights for the organisation. To promote innovation, they showcase progress at the organisational level through project closures and internal presentations, fostering a culture of constant innovation where each achievement and challenge serves as a cornerstone for the ongoing progress of their unit and the organisation as a whole. An illustrative example is the collaborative project conducted in 2021 testing AI and ML technologies for 5G-connected traffic management with a telecommunications company and operational traffic control units, resulting in a positive outcome and subsequent integration into itemized plans through adjusted contracts. The project was submitted to the Latam Smart City Awards, where it emerged as winners in the digital transformation category.

Challenges and opportunities

The Ministry of Transport and Telecommunications, in conjunction with the Chilean government, confronts obstacles to innovation in the transportation and road infrastructure sector, including regulatory constraints, budgetary rigidity, and organisational resistance to change. To address these issues, the unit identifies innovation opportunities, forges partnerships with the private sector and academia, and collaborates with national and international stakeholders. The unit also engages with networks and organisations like APEC, pursuing funding and technical support from entities such as the IDB and the World Bank. Potential innovative approaches for the transportation sector include user-centered design, agile methodologies, data integration, open collaboration, and the implementation of circular economy principles. These strategies enable transportation and road organisations to enhance adaptability and responsiveness to evolving challenges in their environment.

ETHIOPIA - ETHIOPIAN ROADS AUTHORITY (ERA)

Introduction

The Ethiopian Roads Authority (ERA) is a government agency responsible for the planning, development, and maintenance of Ethiopia's road infrastructure. Established to address the country's transportation needs, ERA plays a crucial role in promoting economic growth and accessibility by overseeing the construction and upkeep of a vast network of roads across Ethiopia. With a focus on improving road connectivity, safety, and sustainability, ERA is instrumental in fostering national development, facilitating trade, and enhancing transportation access in both urban and rural areas.

Approach to innovation

Over the past 24 years, the Road Sector Development Program (RSDP) has led extensive road construction, upgrading, and rehabilitation efforts, but issues pertaining to quality, time, and cost overruns necessitated innovative solutions. The ERA has adopted a primarily top-down approach to innovation, driven by senior management's commitment to enhancing road construction and maintenance through new technologies and methods while reducing costs and time. This led to the establishment of the Road Research Centre (RRC) in 2018 with ambitions to not only benefit Ethiopia but the wider region. ERA has fostered innovation by creating an environment conducive to researchers, including the development of a high-standard research facility, tailored salary packages, housing, and other benefits. Currently, everyday research activities dominate the RRC's work, with ongoing upgrades to the research laboratory and a shift toward more strategic innovation projects in the pipeline.

Managing a culture of innovation within the organisation

The ERA has a Director of Research responsible for overseeing all research activities at the RRC. ERA operates a formal ideas program that collects suggestions for improvement from work units within the organisation. They do not have a specific mentoring program, but the Research Director and senior experts actively engage in supporting and training junior researchers. There is also a 5-year technical support program provided by international consultants at the RRC to mentor and build the capacity of researchers and the research centre. While there isn't a specific reward mechanism for research projects, ERA offers incentives like housing and enhanced salary packages to attract and retain researchers. Failed innovations are considered as opportunities for learning rather than failures. Workshops are conducted at various levels to train and motivate the workforce to handle rapid or disruptive innovation, focusing on sharing the outcomes of research.

Encouraging innovation in partner organisations or supply chain

The ERA fosters a culture of innovation among partners and stakeholders by incorporating dedicated contract provisions that allow contractors to allocate budgets for research activities within their projects to ensure the contractor's active involvement in research efforts. The organisation actively engages in promoting innovation through an annual research conference, which welcomes participants from the road sector. ERA also participates in local research workshops related to road and transportation and collaborates with local universities in similar research-focused events. While the organisation previously engaged in international workshops, budget constraints have limited their participation to online and free workshops.

Identifying and evaluating innovations

The ERA actively anticipates future trends and developments to identify innovation opportunities, with the Research Director overseeing this task. Innovations within ERA are typically handled by the RRC, led by the Research Director and his team, who detect and identify innovations occurring within the organisation. To evaluate risks associated with particular innovations, ERA follows a procedure to test their suitability for local conditions and environmental impact, rejecting innovations with excessive risks. The assessment of benefits and value for money for new ideas is carried out by the Research Management Committee who make funding decisions, supported by the Research Director and his team through their assessment of the potential benefits and outcomes. The evaluation process is not solely the responsibility of senior management, as the Research Management Committee, chaired by the Director General or a delegate, plays a crucial role in approving research proposals and budgets. The Research Director is responsible for identifying and organising research ideas and proposals for presentation to the Research Management Committee.

Implementing innovations

Innovation at the ERA is funded through the capital budget, with annual allocations to the Road Research Centre. ERA does not require or develop proofs of concept or minimum viable products for innovations. The organisation employs a user-centric approach as a methodology for developing ideas and solutions.

Managing and monitoring innovations

The ERA measures the success of innovations on impact on cost, quality, and technical performance indicators as outlined in specifications. Lessons learned when implementation falls short of expectations are reported and filed at the research centre. Innovations are institutionalized through workshops, including an annual research conference. ERA maintains a dedicated team responsible for curating all research and innovation works, collecting contributions from other institutions and universities. The organisation communicates research outputs internally via workshops and office memos for implementation, with subsequent reports on the impact presented to top management. These findings are also shared during the annual research conference and the general assembly, where performance and related matters are discussed.

Challenges and opportunities

The ERA is addressing their key barrier to innovation, a lack of strong research culture, by introducing incentives for professionals interested in research, including housing and higher salary scales. Additionally, ERA has facilitated postgraduate study opportunities to encourage academic development among research staff. The organisation has actively participated in the Africa Community Access Partnership (AfCAP) and Research for Community Access Partnership (ReCAP) research programmes and currently collaborates with local universities on joint research programs. ERA plans to expand its collaboration to Eastern and Middle African countries for joint research projects, which aligns with the reorganisation of its research centre. Preparations, such as establishing guest houses and upgrading research laboratories, are underway to support international cooperation and research partnerships.

GERMANY - DIE AUTOBAHN (DA)

Introduction

Die Autobahn GmbH des Bundes of the German Federal Government (in short, Die Autobahn) assumed full responsibility for planning, constructing, operating, managing traffic, maintaining, financing, and managing assets for Germany's motorways on January 1, 2021. This merger combined decades of experience from the 16 federal states and leverages new technological developments to create a modern and innovative entity, aiming to enhance transportation safety, efficiency, and sustainability. To achieve this, Die Autobahn focuses on developing, testing, and rapidly implementing innovative technologies and business models that emphasize usability, safety, and sustainability, driven by advancements in renewable energy, digitalization, and climate protection.

Approach to innovation

Die Autobahn's innovation department supports innovative approaches, encompassing road surfaces, structural engineering, intelligent traffic systems, and efficient operations, with the ultimate goal of designing a future-ready infrastructure that facilitates new mobility forms, renewable energies, safety, and innovative business models through modernized products and processes. As for the approach to innovation, the Innovation Department of the Die Autobahn employs a multi-level approach:

- Top-Down: Innovation priorities are determined by managing directors and communicated through a quarterly innovation committee.
- Mid-level: Managers at all levels are encouraged to experiment with innovative approaches in their projects, with additional funding available through the Innovation Department when project budgets fall short.
- Bottom-up: Every employee can submit ideas for the innovation prize.
- Open innovation: External partners from the private and public sectors can also propose innovation projects to the Innovation Department.

Die Autobahn has explicit strategies outlined in its innovation strategy, "Put innovation first – innovation management at the Autobahn GmbH," which fosters both major strategic innovations and smaller everyday innovations. These innovations are interconnected, such as the use of drones for everyday innovation, supporting the overarching strategic goal of digitalising asset management.

Managing a culture of innovation within the organisation

Die Autobahn maintains an Innovation Department led by a senior manager, reporting directly to the director level. The company employs an innovation prize, offering financial rewards to winners, while also encouraging employees to engage with the Innovation Department for idea submission. However, there is no formal mentoring program in place. With regards to staff recruitment, the organisation only explicitly addresses innovation for specific roles within the Innovation Department. Employee evaluations do not include innovation as a component. There is an Innovation Board which holds quarterly meetings, with the participation of 50-60 members from various departments. Die Autobahn actively supports staff involvement in advisory boards for national and international research projects, bridging the gap between research and practical application. The company has an innovation facilitator responsible for promoting and demanding

innovation by creating conducive conditions, fostering collaboration, and driving targeted innovation processes while identifying innovative needs and priority topics for pilot projects.

Encouraging innovation in partner organisations or supply chain

Die Autobahn cultivates a culture of innovation among partners and stakeholders through targeted network management, global research engagement, interactions with startups, and collaboration with cooperation partners. While innovation is considered in the assessment of suppliers or partners, it is only an evaluation criterion when specific procurement activities explicitly seek innovation; standard procurement activities do not include it. It regularly conducts innovation workshops with sister organisations from neighbouring countries and actively participates in innovation competitions, such as DB mindbox Co-Innovation Program, Energy Storage Challenge, Co-Creation Challenge, and the European Startup Prize, to drive innovation and explore creative solutions in highway infrastructure.

Identifying and evaluating innovations

Die Autobahn‘s approach to anticipating future trends and identifying innovation opportunities involves analysing the effects of mega trends on the organisation's goals as outlined in their Innovation Strategy. The innovation portfolio is shaped not only by disruptive technology but also by disruptive conditions affecting daily operations, such as aging infrastructure and workforce challenges. Innovations are detected through "expert boards" focusing on various topics, and the Innovation Board serves as a central hub for identifying innovations across the organisation. When evaluating innovations, there is an expert assessment presented to the innovation committee which considers various types of risks, including regulatory, reputational, and political. The evaluation process includes experts from different organisational levels and units to ensure innovation is supported throughout the organisation, allowing staff to implement innovations without sole reliance on senior management approval.

Implementing innovations

Innovation funding and budgeting come from various sources within the organisation, including the budget of the Innovation Department, as well as external organisations, such as national research and innovation programs. Their goal is to integrate more innovations into the regular project and maintenance budgets of the organisation. In most cases pilot projects are undertaken before wider deployment activities to establish proof of concept for innovations. The need for minimum viable products varies based on the specific innovation, with technological standards often guided by standardization bodies.

Managing and monitoring innovations

Die Autobahn evaluates the success of its innovations through an innovation project portfolio and regular project progress assessments, focusing on metrics such as budget, timeline, and defined goals. Lessons learned from projects that don't meet expectations are recorded in a similar manner. Institutionalization of innovations is achieved through the Innovation Committee and the Innovation Board. Currently, the organisation does not have specific methods or systems for knowledge management. The promotion and demonstration of the impact of implemented innovations vary based on the innovations' significance and their level of interest on political or societal fronts.

Challenges and opportunities

A primary challenge to innovation is the workforce's limited time capacity for engagement in innovation activities. To address this, the Innovation Department seeks to alleviate the administrative burden and support staff in participating in innovation initiatives. Die Autobahn maintains close links to national and European innovation and research activities, leveraging their connections to national innovation agencies, financial support mechanisms, and regional calls for projects. It recognizes open innovation as a relevant and applicable concept for transport agencies, fostering collaboration and the exchange of ideas with external partners.

INDIA - INDIAN ROADS CONGRESS (IRC)

Introduction

The Indian Roads Congress (IRC) is a preeminent professional organisation in India, dedicated to advancing the field of road transportation and infrastructure. With a rich history and extensive expertise, IRC serves as a vital platform for knowledge exchange and collaboration among professionals in the road engineering and construction sectors. Its primary mission is to develop and disseminate best practices, standards, and guidelines, playing a pivotal role in shaping and enhancing the quality of India's road infrastructure. IRC serves as a driving force behind innovation and excellence in the field of road engineering, making it a central institution for advancing India's road transportation network.

Approach to innovation

The IRC actively promotes innovation by implementing enabling provisions in its manuals, standards, and guidelines. It fosters innovation through various technical committees and has published and revised several standards and guidelines to bring innovative technologies into mainstream road construction practices. These standards include updates related to geometric design, maintenance of bituminous roads, guidelines for bus ports, safer commute to schools, variable message signs, grade separators, and expressways. Additionally, the organisation holds conferences and seminars to keep up with the latest developments, and collaborates with international associations to incorporate the best global practices into its codes and guidelines. The IRC embraces a forward-thinking approach by actively updating its standards and encouraging innovation in the road construction industry.

Managing a culture of innovation within the organisation

The IRC has a dedicated committee of experts responsible for accrediting new and innovative materials, technologies, and machinery for the road sector. This committee has approved 235 such innovations for trial use in road projects, with successful ones being incorporated into new standards and guidelines. The IRC also has an Additional Director specifically handling innovation and the accreditation of innovative technologies. Innovation is one of the criteria included in the annual performance reports of employees, reflecting the organisation's commitment to fostering innovation. Additionally, there are no penalties for failed innovations within the IRC.

Encouraging innovation in partner organisations or supply chain

The IRC places importance on fostering innovation among its partners and stakeholders, ensuring that innovative ideas are duly valued in their activities. Additionally, IRC conducts brainstorming sessions on various topics to promote innovative ideas. The organisation has established a committee to accredit new materials, technologies, and machinery on a trial basis, further demonstrating its commitment to innovation in the road sector.

Identifying and evaluating innovations

The IRC employs brainstorming sessions to anticipate future trends and developments, aiding in the identification of opportunities for innovation. IRC also relies on feedback from various technical committees to determine priority areas for innovation. However, IRC does not directly assess the benefits or value for money of new ideas for innovation, as it is not an implementing agency.

Implementing innovations

The IRC is responsible for developing National Standards for the road sector, and does not serve as an implementing agency.

Managing and monitoring innovations

IRC's accredited innovative materials and technologies undergo rigorous monitoring via an accreditation committee, with performance assessments provided through quarterly reports from implementing agencies. Accreditation renewal is contingent on sustained product success. Long-term successful products are incorporated into mainstream guidelines and codes, ensuring widespread adoption and impact.

Challenges and opportunities

The IRC operates on a self-sustaining basis without government grants. As a result, funding for innovative ideas, particularly pilot projects, poses a significant challenge. While IRC focuses on accrediting and certifying products, actual implementation is entrusted to various stakeholders such as government authorities, private concessionaires, and contractors. Performance data for accredited products used internationally is collected through relevant global organisations. Additionally, the incorporation of information technology innovations plays a pivotal role in enhancing road and bridge design, construction, maintenance, and operational processes.

ISRAEL - NETIVEI (NI)

Introduction

Netivei Israel is the national transportation infrastructure company in Israel overseeing the planning, design and construction of transport infrastructure, including intercity roads, railways, and an airport. Netivei is driven by entrepreneurship, creativity, and innovation. Recognising its pivotal role in the country's economic and social growth, Netivei Israel actively promotes a fusion of knowledge, entrepreneurship, and technology.

Approach to innovation

Netivei prioritises collaboration with academic institutions, researchers, and entrepreneurs, investing significant financial and administrative resources alongside government bodies to advance innovation in the sector. Their global approach aims to enhance Israel's overall economy by fostering a culture of innovation and original thinking within their divisions. They engage with startup companies and innovation communities, presenting annual challenges and providing financial incentives to support the development of promising technologies, ultimately aiming to launch successful solutions through a competitive tender process.

Managing a culture of innovation within the organisation

Netivei has a dedicated Innovation and Strategy Division responsible for overseeing innovation management. They employ formal procedures to gather ideas and suggestions for improvement from employees and the public, including hackathons, acceleration programmes, and workshops, and have a formal structure, including an ESG community, to facilitate this. While they do not have a formal mentoring program, they do arrange hackathons and acceleration programs that involve employees in mentoring roles. The organisation follows a lessons-learned process for failed innovations. Innovation is considered mainly for roles within the ESG, Innovation, and Strategy Division, particularly in the R&D department and Innovation Centre. There is no formal inclusion of innovation in employee evaluations, but innovation methods are incorporated into occasional workshops and training sessions, with plans to implement a program for encouraging an innovation culture, including the appointment of innovation ambassadors.

Encouraging innovation in partner organisations or supply chain

Netivei fosters a culture of innovation among partners and stakeholders through industry education provided by Netivim College, which is a training centre for road professionals. Training includes free online lectures, workshops, and the introduction of new concepts at industry gatherings and conferences. They also use incentives and rewards in development projects. However, innovation is not considered as an assessment criterion in the selection of suppliers or partners due to limitations in ongoing tendering procedures. The organisation actively participates in innovation-related events at both national and international levels, such as conferences, workshops, and competitions, including Hackathons and acceleration programs following an Open Innovation approach.

Identifying and evaluating innovations

Netivei anticipates future trends and opportunities for innovation through its Strategy Department, which evaluates potential innovation areas related to transportation models, materials, and methods. The organisation identifies innovations happening internally by recording new processes and ideas and monitoring the number of implementations in progress. When evaluating a particular innovation, risks are assessed through the Chief Risk Officer and by incorporating lessons learned

from past processes, considering regulatory, financial, and reputational risks. The assessment of benefits and value for money involves financial division assessment, expert opinions, and evaluations of various impacts. The evaluation process includes middle and senior management, with employees empowered to implement innovations with middle management approval. Netivei Israel actively works to create an innovative ecosystem at the national level and within the infrastructure sector.

Implementing innovations

Innovation at Netivei is funded through an annual and multi-annual budget, including allocations of 50 million ILS for R&D and innovation project implementation, 270 million ILS for a portfolio of consulting and R&D projects execution, and 8 million ILS for joint cooperative funding through competitive calls in collaboration with the Innovation Authority. The organisation requires proofs of concept for innovations, particularly in the form of trials, and develops minimum viable products for goods and services. Netivei Israel utilizes its own methodology for developing ideas and solutions.

Managing and monitoring innovations

Netivei utilises tailored metrics to measure the success of innovations, such as the absence of bids for challenge tenders indicating an immature market. Lessons learned from implementations that do not meet expectations are recorded in a repository established since 2023 and reported to the CEO. The organisation institutionalises innovations through the Innovation Center, employing various methods like hackathons, innovation committee meetings, and training programs for employees and the industry conducted by Netivim College, a training center for road professions. Netivei has knowledge hubs and division repositories on SharePoint, and they have attempted to implement a professional innovation management system, Q-market. The impact of implementing innovations is promoted and demonstrated through social media channels, including Facebook and LinkedIn, as well as podcasts. Netivei also participates in national and international conferences, and the activities of the innovation committee are reported to the CEO and the Board of Directors.

Challenges and opportunities

Netivei has identified key barriers and challenges to innovation within the organisation, such as legislative and regulatory hurdles for state-owned companies. They address these challenges through ongoing dialogues with regulators, emphasizing trust and transparency. Overcoming the fixed mindset of employees and managers and adapting to rapidly changing technology are additional challenges. Netivei invests in learning and development to acquire new skills, offering lectures and workshops for knowledge and skill development. Strategically, the organisation faces challenges in monitoring key trends that impact the performance of national road authorities and turning these challenges into opportunities. Tactically, scaling up successful innovations from the proof of concept stage is a primary challenge. Netivei liaises with and benefits from other national and international bodies by collaborating with the Israeli Innovation Authority, participating in Horizon 2020 and Horizon Europe consortia, and co-funding competitive calls in transnational R&D programs. They also consider concepts and approaches from other industries, such as systems engineering, agile project management, user-centric design, and innovation management methods like MVP and lean canvas.

KOREA - KOREAN EXPRESSWAY CORPORATION (KEC)

Introduction

Korean Expressway Corporation (KEC) is a government-owned corporation in South Korea responsible for planning, constructing, managing, and maintaining the nation's expressways and major highways. As a key player in the country's transportation infrastructure, KEC is committed to ensuring safe, efficient, and well-maintained road networks that facilitate economic growth and enhance connectivity. With a focus on innovation and sustainability, KEC leads various initiatives to advance the quality and performance of South Korea's expressway system, contributing to the nation's overall development and competitiveness.

Approach to innovation

KEC is driven to innovate by various challenges, including evolving automotive technologies, changing user needs, limited resources, safety concerns, climate change, and decreased government financial support for Social Overhead Capital projects. Their innovation drivers are centred around customers, addressing climate change, and improving organizational efficiency. KEC's approach to innovation involves a top-down and bottom-up strategy. They have set a new company vision, "safe and convenient future road platform company," with four key strategies. These strategies are defined through collecting ideas from various specialist groups and individuals across the country. KEC actively allocates innovative projects to divisions, evaluates their outcomes, and incorporates the results into performance evaluations and rewards. Additionally, they encourage bottom-up innovation by having a system where employees can propose new ideas, with rewards and recognition for contributors. While strategic innovation takes precedence, everyday innovation is also institutionalized to encourage employee participation in organizational innovation.

Managing a culture of innovation within the organisation

KEC assigns various positions to oversee innovation in different areas, including collecting everyday and strategic ideas, adopting new technologies, and digitalizing maintenance processes. These roles include a managing director and team, a future strategy managing director and division, a CEO-centred special team for technology adoption, and a digital expressway promotion division for maintenance digitalization. KEC encourages staff to suggest improvements through official suggestion programs, including Quick-win and the annual innovation competition. These suggestions are evaluated based on feasibility, cost, scalability, and impact on end-users. To incentivize innovation, KEC employs a rating system and provides rewards such as prize money, prizes, and extra points for annual performance evaluations. Exceptional contributors may also gain promotion advantages, and if innovations lead to budget savings or increased sales, a portion of those gains is awarded to the staff or teams involved. Innovation is considered as part of employee evaluation and performance assessments, reflecting the degree of innovation in their work and outcomes.

Encouraging innovation in partner organisations or supply chain

KEC fosters a culture of innovation among partners and stakeholders through regular knowledge sharing sessions with subsidiaries and proposing innovative initiatives to the central government, such as the lane colouring system for easier navigation at interchanges. For road users, KEC runs a people participation program to gather their improvement ideas, rewarding those with the best

suggestions. In supplier selection, KEC follows strict government regulations, with 20 percent of the evaluation based on technical criteria, considering factors like ESG, new technology, safety, and user convenience. KEC actively participates in annual government-led innovation competitions and undergoes a management evaluation by the government to determine incentive levels, with innovation being a critical factor in receiving high ratings.

Identifying and evaluating innovations

KEC has various divisions focused on anticipating future trends and road users' evolving needs. These divisions continually research current trends and environmental factors to shape new management directions. The evaluation of the benefits and value of innovative ideas is based on comparing the outcomes before and after implementation, considering factors such as cost-efficiency, time-saving, resource utilization, user-friendliness, and changes in sales. The evaluation process involves multiple steps, including mobile voting by workers, middle-level evaluation committees, final committees comprising outside specialists and executive directors, and regular performance reviews for both everyday suggestions and strategic innovations.

Implementing innovations

KEC funds and budgets officially recognized innovation projects through its board of directors. The funding approach depends on the project's characteristics, with government projects funded by the government's budget and pure KEC projects funded by issuing corporate bonds. KEC employs user-centric and rapid development methods, focusing on enhancing road users' convenience and addressing rapid environmental changes affecting road infrastructure. Proofs of concept are typically required for innovations, aiming to improve current processes efficiently and ensure reasonable outcomes before implementation by comparing the before-and-after scenarios.

Managing and monitoring innovations

KEC measures the success of innovations through cost savings, end-user satisfaction, time-saving in work processes, and the spread of new methods within the organization and stakeholder engagement. Recognized innovations are institutionalized through regulatory changes, internal work manuals, and a knowledge management system, with information shared on the official website. The impact of implemented innovations is promoted internally through the intranet, and externally to road users via newspapers, broadcasting, and the utilization of expressway facilities like rest areas and tollgates.

Challenges and opportunities

Key barriers and challenges to innovation for KEC include regulatory constraints in the management of road facilities, stringent safety regulations leading to higher costs, limited workforce, and financial resources. Resistance to new methods from staff and suppliers is also a significant barrier. KEC draws inspiration from best practices in both public and private industries, benchmarking and participating in relevant forums and events. Examples of potential innovation sources for KEC include developments in automotive technology, electric vehicles, drone technology, and Building Information Modeling (BIM) for infrastructure design and maintenance. Additionally, KEC explores new organizational cultures that promote productivity and reduce internal conflicts, such as adopting horizontal structures and offering substantial rewards to incentivize innovation.

MEXICO - MEXICAN INSTITUTE OF TRANSPORT (IMT)

Introduction

The Mexican Institute of Transport (IMT), established in 1987 under the Secretary of Infrastructure, Communications, and Transport, is a research and technology development centre specializing in transport. IMT aims to promote innovation, competition, and the creation of greater economic value with a sustainability focus. Recognizing that innovation is key to enhancing productivity and competitiveness, IMT has been committed to generating innovation through scientific research projects and the development of technologies to improve the transport sector's efficiency and enhance the quality of life for the population. IMT operates within a decentralized administrative framework to ensure technical, functional, and managerial autonomy while aligning with public policies and guidelines set by higher authorities.

Approach to innovation

IMT adopts a versatile approach to innovation encompassing both top-down and bottom-up elements. Innovation is a daily practice at IMT, stemming from research activities categorized into two streams: internal research initiated by researchers and approved by the Committee for the Selection of Internal Research Projects, and external research triggered by requests from government entities or private sector entities aligned with IMT's strategic plan. This approach integrates both vertical (top-down) and horizontal (bottom-up) dynamics, with innovation ideas originating from researchers, senior figures within IMT, or requests from the Secretary of Infrastructure, Communications and Transport, fostering multi-coordination projects. IMT maintains a strategic plan that is revised every five years, aligning with national development plans and sector-specific programs. This strategic framework guides IMT's policies and objectives, encompassing air, maritime, and land transport, as well as telecommunications and radio broadcasting.

Managing a culture of innovation within the organisation

IMT is led by the Director General, who is responsible for directing institutional innovation projects, scientific research, and post-professional training, with a focus on the development and strengthening of the transport sector in Mexico. In terms of staff suggestions for improvement, IMT follows a formal process with regular review and action follow-up meetings. Improvement proposals are formalized into "Improvement Projects" that are integrated into IMT's Quality Management System. IMT offers a training program focused on ethics and public integrity, including participation in courses, seminars, and conferences to enhance the capabilities of its staff. IMT recognizes the value of its human resources and encourages postgraduate studies through financial support scholarships. Trainees completing their programs are granted paid leave of absence. Failed innovations are subject to evaluation, and if rated as "unsatisfactory," corrective action plans are implemented.

Innovation is a significant factor in the recruitment process, particularly for researchers, based on metrics like authored publications. Innovation is also included in employee evaluations, assessed through technical publications, research reports, event organization, attendance at seminars and conferences, and participation in committees.

Encouraging innovation in partner organisations or supply chain

IMT fosters a culture of innovation in its partners and stakeholders through various means: disseminating a culture of innovation through communication criteria, offering post-professional refresher courses based on staff innovation results, regularly publishing seminars on innovation on its official website and YouTube channel, and seeking agreements for joint support actions with various national and international organizations. However, innovation is not currently included as an assessment criterion in the selection of suppliers or partners, and the organization participates in innovation workshops and conferences as part of its performance assessment activities.

Identifying and evaluating innovations

IMT anticipates future trends and developments through the Guidelines for the Technological Roadmap of Land Transport in Mexico, the National Development Plan 2019-2024, and IMT Strategic Plan. They also maintain an Information and Documentation Centre to keep their staff informed and engaged with national and international institutions. Innovations in the organization are identified from documentation, improvement projects, and finished deliverables within annual institutional goals. They evaluate risks using a SWOT analysis and conduct risk management procedures at the project level, involving IMT Coordinators and project review committees. To assess the benefits and value for money, project evaluations are conducted by Coordinators, with failed evaluations leading to corrective actions. The approval of senior management and committees is required for project implementation, with staff empowerment subject to prior authorization.

Implementing innovations

Internal initiative research projects are financed using the annual budget allocated to the Institute, approved by the Secretary of Infrastructure, Communications and Transport. For external initiative research, a technical-economic proposal is prepared, and the external party must accept and meet payment conditions before project development begins. Proofs of concept are developed for some innovations, involving procedural, physical, or mathematical prototypes, considered as intermediate products. Minimum viable products are required for all applied research work, resulting in products such as Technical Documents, Manuals, or Technical Publications. IMT's approach to innovation doesn't prioritize rapid development but rather follows a strategic foresight approach based on predefined future scenarios. The institute employs a production methodology and a quality system, which is continuously updated to meet the Institute's evolving needs, aligned with the Plan-Do-Check-Act (PDCA) cycle adopted by ISO 9001:2015.

Managing and monitoring innovations

IMT measures the success of its innovations through performance indicators tied to the fulfilment of goals set for each area, including metrics like the Completed Research Projects Index and the Completed and Delivered Tests Indicator. Customer Satisfaction is another indicator, assessed through stakeholder satisfaction with project deliverables. Lessons learned when implementations fall short are informally retained and not systematically documented. Innovations are institutionalized through internal communication and knowledge dissemination, facilitated by specific criteria and communication matrices. Internal dissemination is conducted via the Document Distribution System, an official website, and a weekly Transport Seminar to share project results. IMT practices knowledge management to control and manage the stages of knowledge generation, dissemination, externalisation, combination, and internalisation. Impact is

demonstrated through active participation in national and international events, publication of research results, and the "NOTAS bulletin" which is distributed both internally and externally on a monthly basis to showcase research outcomes and promote a culture of innovation among the general public.

Challenges and opportunities

IMT faces a significant challenge in terms of its annual budget, as it relies on federal fiscal resources in the public sector, limiting its material and human resources for innovation. Efforts have been made to address this issue by generating additional resources through external initiative projects, although the process is slowed down by VAT deductions and administrative procedures for resource recovery. IMT collaborates with other national and international bodies by encouraging the participation of specialized personnel in committees, aiming to identify best practices and promote technology transfer for the benefit of the country. Additionally, IMT establishes agreements and relationships with educational institutions to offer postgraduate training and continuing education opportunities in the field of transport with an innovation-focused approach. IMT can draw from concepts like Lean Manufacturing, Open Innovation, and Project Management, which have relevance in improving processes and products, fostering external collaboration, and structuring project management methodologies for the road and transport sector.

UNITED KINGDOM - NATIONAL HIGHWAYS (NH)

Introduction

National Highways (NH), previously known as Highways England, is a government-owned company in the United Kingdom responsible for managing and maintaining the country's major road network. Tasked with delivering safe, efficient, and well-connected road infrastructure, National Highways plays a pivotal role in ensuring the mobility of people and goods across the nation. With a strong commitment to innovation, sustainability, and safety, National Highways leads efforts to enhance the quality and reliability of the road network, contributing to economic growth, environmental objectives, and overall transportation excellence in the UK.

Approach to innovation

The organisation emphasizes its commitment to innovation and research, addressing current challenges while preparing for the future. This future involves improving safety, efficiency, and decarbonization of the network, as well as meeting individual customer needs. They recognize their role in contributing to broader UK transportation and mobility goals, including net zero carbon targets, while supporting the national economy and construction industry. The organisation has outlined its research and innovation goals across five interconnected themes, emphasizing safety and sustainability. They prioritise five major challenges, including achieving net zero carbon emissions by 2050, zero harm by 2040, faster and more cost-effective construction by 2030, connected journeys by 2035, and fostering research and innovation excellence across the industry by 2025. The innovation portfolio will be structured with investments distributed across short, medium, and long-term horizons, with a shift towards a 70/20/10 split.

Managing a culture of innovation within the organisation

The organisation has a Director of Innovation and a dedicated Head of Innovation. They operate an Innovation and Modernization Designated Fund with an associated program for both internal and external innovation ideas. A general mentoring program is in place, and the organisation offers a rewards program called "high five" for employees who go above and beyond their regular duties. Recruitment processes vary based on specific roles, and innovation is incorporated into employee evaluations for roles associated with innovation. Training and motivation for rapid or disruptive innovation are supported through the organisation's learning platform and the Supply Chain Sustainability School, providing accessible learning opportunities for staff.

Encouraging innovation in partner organisations or supply chain

The organisation encourages innovation in its supply chain through contractual clauses, tender requirements, and the funding of innovation ideas, provided they have a National Highways employee Project Sponsor and a Procurement strategy. Innovation is considered in the assessment criteria for selecting suppliers or partners, especially in new contracts and frameworks. The organisation actively participates in innovation workshops, conferences, and competitions, having organised multiple innovation workshops and an accelerator program in recent years.

Identifying and evaluating innovations

The organisation's Innovation team is responsible for anticipating future trends and developments to identify innovation opportunities, including completing technology foresight projects. Innovations within the organisation are tracked through various Innovation and Research projects

managed by the Programme Management Office. When evaluating a particular innovation, the Project Sponsor, in collaboration with technical specialists, assesses the associated risks and provides mitigation strategies. The assessment of benefits and value for money is conducted by the Project Sponsor and technical specialists, considering various factors beyond financial returns. The evaluation process involves Technical, Commercial, and Innovation Specialists, Senior Management, and the Programme Management Office, particularly for innovations requiring funding, while staff are empowered to implement innovations that don't require formal approval.

Implementing innovations

Innovation is funded and budgeted for through the Roads Investment Strategy, including designated funds like the Innovation & Modernisation Designated fund and the Research and Development fund. The development of proofs of concept and minimum viable products varies based on specific projects. Project teams employ various methodologies to develop ideas, and there is guidance available in the form of the Pilots and Trials Guidance document for the development and trialling of new products.

Managing and monitoring innovations

The success of innovations is measured and tracked through an Efficiency Tracker, contributing to overall efficiency targets. Lessons learned from implementations are recorded in a Knowledge Bank. Innovations are institutionalised through a funding process that requires a plan for becoming a regular part of the business. Knowledge management is facilitated through a Knowledge Bank and an Innovation Portal, and the organisation promotes and demonstrates the impact of innovations through active communication, especially regarding innovation competitions, to both internal and external stakeholders, including elected officials and the general public.

Challenges and opportunities

Key barriers and challenges to innovation include financial/resource constraints, balancing immediate operational challenges with future preparedness, and influencing the supply chain to embrace innovation. Responses include focusing innovation through themes and ambitions, maintaining a balanced portfolio, partnering for collaborative projects, and early engagement with challenges.

The organisation liaises, influences, and benefits from national and international bodies regarding innovation policies through active participation in various groups, including TRIB, i3P, ICG, and CEDR research and innovation working group. Additionally, collaboration with entities like Catapults, Innovate UK, and the Manufacturing Technology Centre is facilitated through membership and specific framework agreements.

Processes, concepts, and approaches applicable to roads and transport organisations can be drawn from infrastructure sectors, industries heavily reliant on supply chains, and safety-critical sectors. Adopting concepts from the tech industry, such as Agile project management, business model canvassing, and product management principles, can aid in the digitalisation of processes and operations.

UNITED STATES - FEDERAL HIGHWAY ADMINISTRATION (FHWA)

Introduction

The U.S. Department of Transportation's (U.S. DOT) Strategic Plan for Fiscal Year 2022-2026 outlines a transformative vision to modernize the country's infrastructure for safer, cleaner, and more equitable transportation systems. The Federal Highway Administration (FHWA), as a key modal unit of the U.S. DOT, closely aligns with this plan, particularly focusing on "Transformation" and "Organizational Excellence," which highlight the importance of research, innovation, and an inclusive culture.

Approach to innovation

FHWA has a history of championing innovations, and established the Accelerating Innovation program team in April 2012 to coordinate internal and external efforts in identifying and prioritizing innovations. The Technology Innovation Deployment Program (TIDP), enabled by U.S. Congress legislation and implemented by FHWA, plays a vital role in translating research into proven technologies and demonstrated practices. FHWA's approach to innovation is best described as "stakeholder-driven," with the American Association of State Highway Transportation Officials (AASHTO) as a primary stakeholder. FHWA collaborates with AASHTO's Special Committee on Research and Innovation to foster transportation research and innovation. The balance between strategic innovations and everyday or incremental innovations is actively managed through programs like Every Day Counts (EDC) for transformative-scale innovations and State Transportation Innovation Council (STIC) Incentive programs for incremental-level innovations, ensuring their potential impact is maximized.

Managing a culture of innovation within the organisation

FHWA designates a Senior Executive Service-level leader responsible for innovation. This leader coordinates initiatives related to enhancing the transportation workforce through technical training, assistance, and technology deployment, working separately from FHWA's senior leadership in Research, Development, and Technology. FHWA encourages innovation through the "DOT IDEAS" program, allowing all employees to contribute ideas directly, fostering a transparent and open forum for idea sharing. Several state DOTs run individual idea programs or innovation challenges, with FHWA playing a role in information exchange and raising awareness of these efforts. FHWA administers a formal mentoring program with mentor-mentee matches, focused on achieving specific development goals. Another program, Innovative and Exceptional Partnerships (IEP), fosters effective partnerships between FHWA leaders and State CEOs to enhance an innovation culture. To motivate the workforce for innovation, FHWA manages the Discipline Support System (DSS), bringing individuals together in various disciplines across the agency, encouraging knowledge sharing and innovation by design through structured exercises like table-top innovation models that generate tangible, implementable ideas within a short timeframe.

Encouraging innovation in partner organisations or supply chain

FHWA's approach to creating and supporting a culture of innovation in partners and stakeholders centres on relationship-building, communication, and collaboration. The agency collaborates with various stakeholders, including government agencies at different levels (Federal, State, Tribal, and local), academic institutions, private entities, and advocacy groups. FHWA ensures communication and coordination occur at all levels, fostering an environment of openness and partnership. The

Accelerating Innovation team promotes collaboration through the STIC network, enabling stakeholders to evaluate and implement innovations tailored to their needs. Informal gatherings of "Innovation Officers" provide a space for sharing experiences and knowledge, supporting the ongoing advancement of innovation across the country.

Identifying and evaluating innovations

FHWA's flagship technology deployment program EDC focuses on underutilized innovations that, with broader adoption, can enhance the American transportation system. A stakeholder-driven approach is employed, involving internal subject matter experts and collaborating with State, local, industry partners, and the public to identify proven, market-ready innovations. FHWA recently called for innovation suggestions, seeking input from FHWA, primary stakeholders, and the general public, evaluating each proposal's national impact, transformative potential, urgency, and readiness. The Accelerating Innovation team facilitates the review process, considering resource constraints and risks. The final selection is made by FHWA Executive Leadership, based on feedback from key transportation organizations, ensuring the innovations serve the national transportation program's greater good. The Accelerating Innovation team manages the program's delivery.

Implementing innovations

FHWA's funding and budgeting for innovation primarily come through the TIDP, allowing flexibility for activities like deploying research results, demonstration programs, technical assistance, and improved tools. Innovations included in the EDC program have budgets and Implementation Plans developed based on States' market demand, including technical assistance and various formats of knowledge sharing. FHWA's Accelerating Innovation unit also supports innovation deployment through the STIC Incentive and Accelerated Innovation Deployment (AID) Demonstration programs, providing financial incentives for their implementation, with up to 10 million US$ available annually. Proofs of concept are not directly required for these programs, but the readiness level of innovations, typically TRL 7 or higher, plays a role in their eligibility. These programs facilitate the adaptation of technologies from other sectors into the transportation domain, fostering innovative solutions like nanocoating for corrosion protection, previously used in military, marine, and oil and gas industries, thus enabling innovations to thrive in an operational transportation environment.

Managing and monitoring innovations

FHWA measures the success of innovations through the EDC program, tracking their implementation through baseline reports and progress updates. Baseline reports describe the state of practice and implementation goals for innovations, which are tracked every six months. Lessons learned from implementation, including challenges and successes, are recorded and shared through media and technology transfer efforts. Institutionalization of innovations is defined within the EDC program as their adoption as standard practices by states. Knowledge management is facilitated through EDC as it exposes the transportation workforce to new practices. To promote and demonstrate the impact of innovations, FHWA employs various communication channels, including web pages, social media, videos, newsletters, and peer-to-peer exchanges, to inform both internal and external stakeholders, elected officials, and the general public about the successes and progress achieved with implementation efforts. Specific initiatives supported through the TIDP also require regular reports to demonstrate progress to elected offices.

Challenges and opportunities

The United States faces challenges to innovation that are common to many countries. To address these challenges, FHWA emphasizes the need for champions and advocates of innovation at various levels. They promote a "top-down" and "bottom-up" approach and encourage the presence of multiple champions with different skills, such as subject matter experts, effective communicators, and networkers. Furthermore, creating a safe space for discussing innovation and calculated risks is crucial, particularly in the traditionally conservative transportation industry. Engaging a diverse range of stakeholders, including federal, state, local, industry, consultants, and academia, is essential for advancing national and local-level efforts. Lastly, FHWA highlights the importance of clearly conveying the "why" behind an innovation to create a compelling business case for change, emphasizing the potential positive impacts on time, resources, and safety, and leveraging stories from peers to promote adoption.

UNITED STATES - OKLAHOMA DEPARTMENT OF TRANSPORTATION (ODOT)

Introduction

The Oklahoma Department of Transportation (ODOT), since 2006, has significantly improved its ranking in bridge infrastructure, going from 49th to 5th in the nation in addressing structurally deficient bridges. Despite the challenge of managing an aging pavement and bridge infrastructure, ODOT remains committed to sustaining less than 1% of structurally deficient bridges, decreasing traffic fatalities by 5%, improving rural highway conditions, and increasing lane miles in good condition. The agency utilises innovation, including business process enhancements and efficiency tracking, to deliver safe infrastructure within budget limitations.

Approach to innovation

In 2020, ODOT initiated a modernisation effort to enhance efficiency and effectiveness through process improvements, change management, and knowledge management, resulting in time savings and innovative solutions. In 2021, the Office of Innovation was established to lead these modernisation endeavours and foster a culture of ongoing improvement. ODOT collaborates with universities and public partners to access external innovations and documents internal innovations as efficiencies for leadership consideration. The department is in the process of forming an innovation council, bringing together transportation leaders to gain a comprehensive perspective. The Office of Innovation oversees the state research program, federal funds, and participates in pooled fund studies, enhancing the department's knowledge of innovative solutions.

Managing a culture of innovation within the organisation

In recent years, the transportation department's leadership has elevated its commitment to innovation by establishing the Office of Innovation in June 2021, complete with a Chief Innovation Officer, Deputy Chief Innovation Officer, Innovation Program Lead, and contract employees. This office fosters a culture of innovation through personal relationships, recognition of innovative efforts, and the promotion of change and knowledge management. While the engineer-in-training program is not specifically centred on innovation, it contributes to innovative activities. The department's reward program recognises employees who embody guiding principles, which emphasise collaboration, innovation, communication, customer service, efficiency, and adaptability. The workforce is well-versed in providing innovative solutions to address current challenges, and supervisors are equipped to manage disruptions through the Trailblazer Leadership Program.

Encouraging innovation in partner organisations or supply chain

Department staff are actively encouraged to engage in conferences and events where the department is represented, prioritising knowledge growth and fostering a culture of collaboration. In partnership with stakeholders, a holistic approach is advocated for decision-making and change management strategies, with a willingness to embrace a "blank paper" mentality to facilitate innovative thinking and solution development. The department is also exploring innovative approaches to procurement practices within the framework of state procurement laws, with plans to implement projects in a more innovative manner.

Implementing innovations

The Office of Innovation collaborates closely with business units to assess technology readiness levels and select appropriate tools for the Department, offering technology discovery sessions to

gauge user readiness and allocate necessary resources for implementation, including additional training and post-go-live support. The Department utilises an Agile methodology to implement innovations in a phased approach, facilitating readiness by introducing subsets of the technology tool incrementally and reinforcing best practices, training, and process changes. Currently, each business unit independently implements innovations; however, ODOT is developing an Innovation Council to promote a culture of collaborative innovation, complete with communication and change management plans to streamline the implementation of innovations across the Department.

Managing and monitoring innovations

Innovation successes are assessed based on various criteria, including internal metrics such as time, cost, and space savings, and external factors like efficiency and effectiveness for the public and partners. Lessons learned are compiled through review forums and later shared with leadership to understand circumstances when innovations fall short of requirements. The Department employs both quantitative and qualitative measures, including key performance indicators, to gauge innovation success, utilising measurable data and employee feedback. This information is crucial in infusing and sustaining innovative solutions. Documentation, standard operating procedures, and knowledge management are essential for maintaining these solutions. The Office of Innovation is currently working on a knowledge management project through a SharePoint-based internal website, providing employees access to a wide range of information, including lessons learned, SOPs, KPIs, and manuals.

Challenges and opportunities

ODOT values innovation and endeavors to maintain infrastructure and enhance safety within budget constraints. Leadership promotes forward-thinking and inventive solutions for the benefit of the public. Disseminating information poses a challenge due to the state's expansive reach, with rural areas creating communication hurdles with on-ground workers. While technology has improved communication, there are still gaps to address in the near future.

UNITED STATES - UTAH DEPARTMENT OF TRANSPORTATION (UDOT)

Introduction

The Utah Department of Transportation (UDOT) is a dynamic agency at the forefront of transportation innovation, entrusted with enhancing mobility, safety, and quality of life throughout the state of Utah.

Approach to innovation

UDOT has fostered a robust culture of innovation to address Utah's growing transportation demands and limited funding. Their "good roads cost less" approach has been in place for over 25 years. In 2017, they formalized their innovation program, creating a dedicated division and an innovation team. UDOT encourages employees and partners to find creative solutions to improve transportation and quality of life. They aim to take an "All Users" approach, making transportation safer and more reliable. The department collaborates with various partners through an innovation council, as well as contractor and consultant councils, to enhance transportation innovations and efficiencies.

Managing a culture of innovation within the organisation

UDOT's Executive Director has been a driving force in fostering an innovation culture for over two decades. In 2017, structural changes were implemented, creating a senior leadership role focused on Innovation and Technology, and department resources were organised into a matrix to advance mobility and innovation in Utah. The formal innovation engine is the research division, responsible for gathering, reporting, and promoting innovations and efficiencies. A full-time innovation manager, division staff, and regional coordination council ensure outreach and the collection of fully implemented innovations and process improvements. The department publishes an annual report on innovation and efficiency accomplishments, and an online system facilitates idea-sharing and reporting. New employees are encouraged to embrace innovative thinking, and awards and recognitions celebrate a wide range of innovations. An Innovation Council represents various groups and regions, promoting innovation efforts and collecting implementation stories. UDOT participates in national initiatives like FHWA's Every Day Counts and focuses on submitting problem statements and leading the implementation of transportation innovations.

Encouraging innovation in partner organisations or supply chain

UDOT actively engages with national transportation innovation groups and federal programs supporting innovation, such as FHWA's Center for Accelerating Innovation (including Every Day Counts and STIC Network), AASHTO's Innovation Initiative and Innovation Community of Practice, and annual participation in the Transportation Research Board Annual Meeting. The department leads quarterly councils with FHWA, AGC, and ACEC to identify and disseminate innovative solutions for transportation challenges. Additionally, the department collaborates with MPOs, transit agencies, and other state transportation groups through a quarterly council, and is extending its research program to include strategic partners and educational institutions.

Identifying and evaluating innovations

UDOT primarily emphasizes the documentation and promotion of fully implemented innovations, encouraging grassroots development where employees explore innovations under the guidance and approval of their teams. The department embraces the notion that those closest to the work often possess the best insights for solutions, promoting a "do it yourself" ethos. Local team leaders

and regional managers typically have the authority to evaluate and approve innovation implementation. To foster organisational learning, research innovation staff collect feedback and reports from leaders and employees, sharing information and collecting implementation outcomes through statewide visits. The Innovation Council assists in collecting innovation projects through an online form, and reported innovations follow a standard format that outlines the problem, the change made, and the impact. Innovations' impacts and benefits are assessed across four areas aligned with the Quality of Life Framework and reported annually, while ongoing efforts aim to quantify project innovations and their value to the public through external partnerships and contractor involvement.

Implementing innovations

The bulk of UDOT's innovations are funded at the discretion of supervisors and teams, sourced from project budgets, operations budgets, research funding, UTRAC, and, for larger initiatives, through public processes involving the State Transportation Commission. Most innovation costs are managed by the respective teams. The Innovation documentation program has funding earmarked for expanding innovation efforts, primarily used to support the widespread adoption of innovations. For instance, if a maintenance station develops a new tool for sign repairs, and the Innovation council promotes it, other districts or stations may express interest in replicating the tool. In such cases, the research division may allocate funds to facilitate the development of fabrication details and other necessary elements to enable broad-scale implementation of the tool.

Managing and monitoring innovations

The impacts of implemented innovations are communicated across the agency and to elected officials and stakeholders through the annual publication of an Innovation and Efficiency Report, distributed in the fall and available on the website for public access. This report includes information on cost savings (both cost avoidance and reduction) and labour hours saved, which can also be accessed through a system dashboard. Furthermore, the department maintains a research document outlining the value of innovation project initiatives from national training and efforts like TRB, effectively tracking innovation ideas from conception to implementation, and publishing data that underscores the importance of ongoing education and transportation learning from national initiatives such as TRB.

Challenges and opportunities

Grassroots-level innovation at UDOT offers both challenges and opportunities. While formal innovation efforts are well-documented and funded, local-level initiatives may be implemented with less visibility. UDOT's culture of team autonomy can sometimes result in a lack of institutional awareness. However, the benefits of allowing teams to experiment and find solutions often outweigh the need for formal authorization and monitoring. The agency has improved its innovation structure, driven by the changes in 2017, establishing a dedicated innovation research team to track and promote innovations through an innovation council, expediting innovation acceleration. UDOT's adoption of matrix organisation principles has facilitated structured innovation and efficiency efforts, leading to accelerated growth and expertise in various areas, enhancing the user experience for all.

APPENDIX D. PRESENTATIONS AT WRC 2023

BELGIUM , VLAANDEREN - AGENCY FOR ROADS AND TRAFFIC (AWV)

Title of Presentation: Organizational Practices in Innovation

Introduction

The presentation described the role of AWV in responding to and shaping new technologies, and how the Project Management Office (PMO) for Innovation and Change (PIC) is helping to drive the implementation of new technologies. One of the key innovation drivers is the rapid development of Intelligent Transportation Systems, which embodies AWV's commitment to green, user-centric, multimodal, connected, cooperative, and automated solutions.

The agency's focus on innovation is evident through the more than 270 ongoing initiatives that have been identified. The PIC investigated these initiatives through assessing their targets, adherence to timelines, adherence to budgetary constraints, and identification of shared challenges encountered during implementation. The role of the PIC is to unburden project teams, track the progress of innovation projects, and help stimulate an innovation culture throughout the agency.

Innovation Portfolio

One key tool of the PIC is the creation of the innovation portfolio, which divides innovation projects into three time horizons: incremental, new, and disruptive. It also concentrates on change management, specifically identifying the human aspects of change within the organisation in order to try to minimise potential resistance to change.

Guiding Principles

The presentation outlines the guiding principles and focus areas of the agency, providing a comprehensive overview of its strategic approach to maintaining Business As Usual (BAU), implementing necessary adjustments, and navigating changes within the organization. Under the guiding principles, the organization emphasizes the importance of making necessary adjustments to sustain BAU operations. This involves addressing new legislation, identifying gaps, and organising tasks in alignment with available resources. The PIC focuses on corrections within BAU, incorporating feedback audits and optimizing current operations.

The presentation highlights the significance of addressing scope adjustments in BAU related to new assignments, the formation of new teams, merging of existing teams, and the incorporation of extra tasks, recognizing the potential resistance that may arise within the organization. Technological revolution, on the other hand, can involve creation of new tasks, teams and roles. Part of the role of the PIC is to help plan and manage those in advance.

Collaboration

The presentation distinguishes three different types of focus area with regards to collaboration: general and external to the road sector for example using services and resources provided by organisations such as Gartner, McKinsey and the World Economic Forum; involvement with EU Commission on mobility and transport; and specifically in the road sector through collaboration with organisations such as CEDR and PIARC.

Specific focus areas include the development of smart roads through digitisation, including smart infrastructure management, predictive maintenance, and digital condition monitoring utilising technologies such as AI, BIM, IoT, VR & AR, and Digital Twins. The agency also aligns its goals with the EU Green Deal, emphasizing initiatives for CO2 reduction, the circular economy, and the utilisation of renewable energy sources. Another focal point is Connected, Cooperative, and Automated Mobility (CCAM), encompassing aspects like Cooperative Intelligent Transportation Systems (C-ITS), cooperative traffic management, autonomous driving, and digital transport infrastructure including infrastructure for 5G connectivity. The agency places a strong emphasis on business transformation across all of these areas.

Ongoing innovation projects

The presentation provides examples of ongoing projects, such as Mobilidata and Road Works Warning systems. These projects involve broad collaboration among various actors, including cross-departmental, cross-agency, and cross-policy domain collaborations at the international level. The projects are characterized by their strong data-driven approach, focus on both digital and physical infrastructure, incorporation of diverse competences, and a balance between research & development and rollout phases. Change management aspects are also integral to these initiatives.

The presentation also identifies three important domains within the innovation focus area that are closely tied to the ongoing business: Digital Asset Management, Digital Traffic Management, and Digital Construction Zone. These domains underscore the organization's commitment to integrating digital solutions into core operational functions.

Encouraging innovation among staff

While AWV has identified a number of innovation ambassadors, they stress that innovation belongs to everyone whether they belong to the PIC or not. The PIC brings a set of added values to the agency, through providing visibility to their innovations, providing a project approach in terms of project management, providing access to a network of peers, experience with community engagement, specific tools and training, familiarisation with innovative contracts, mentoring, and subsidies.

Recognizing that an organisation standing still is akin to moving backward, the PIC envisions the agency to be more relevant than ever by 2030 for road users. To actualize this vision, the PIC advocates for an open and transparent culture of innovation. This includes providing a calibrated channel and process through which every AWV employee can express their ideas about innovation and necessary change. The PIC establishes networks of like-minded AWV employees passionate about innovation, ensuring that good ideas are not lost amid the daily activities. The team actively acknowledges the inherent connection between innovation and change, manifesting in organizational shifts, evolving services, and altering job content and required competences. The PIC strives to detect potential changes at an early stage and facilitate proper supervision to navigate transformations in the organisation, services, and job content effectively. Through these initiatives, the PIC plays a crucial role in fostering a dynamic and innovative environment within the organization.

SPAIN - DIRECCIÓN GENERAL DE CARRETERAS (DGC) OF MITMA

Title of Presentation: The New Innovation Policy at D-G for Roads (GC), MITMA (Spain)

Introduction

The Dirección General de Carreteras (DGC) of the Ministry of Transport, Mobility, and Urban Agenda (MITMA) in Spain is driving innovation policies for the country's State Road Network (RCE). This comprises 26,459 km of mature network carrying 52.5% of the traffic and 64.75% of the heavy traffic in Spain. The RCE is further divided into the high-capacity network, encompassing just over 17,500 kilometers, of which 1,400 kilometers is tolled. The Directorate-General for Roads (DGC) manages the State network toll-free. MITMA's new approach for the RCE aims to align with broader societal goals. The vision is to consider mobility as an integral part of the overall transportation system. The mission is to promote sustainability, economic development, and social cohesion, and the identified needs are to incorporate innovation and sustainability criteria into the network.

Strategy Overview

MITMA's strategic priorities are closely tied to the evolving landscape of mobility. They are based on the "Mobility Strategy Safe, Sustainable and Connected 2030," which comprises nine key axes. In addition, Spain has introduced the Sustainable Mobility Bill in December 2022, pending parliamentary debate, to set out fundamental principles and objectives for mobility. Complementary regulations address energy efficiency, climate change adaptation, urban integration, the promotion of electric mobility, and the utilization of renewable energies within the road network. This strategic approach underscores Spain's commitment to shaping its transportation infrastructure in line with contemporary sustainability and connectivity standards, fostering innovation and eco-friendly practices in the road sector.

Barriers to Innovation

The DGC faced several barriers to innovation in its previous approach, including a primary focus on infrastructure management instead of mobility management, concerns regarding legal uncertainties and risks associated with untested or non-standard approaches, and a lack of a systematic method for capturing and following up on innovative ideas. The innovation process was sporadic, with a predominantly bottom-up and in-bound approach that often operated separately from formal top-down processes, creating what can be described as a "closed innovation" model. Initiatives for innovation typically originated from internal innovative individuals rather than from top-down development or the updating of technical standards or instructions. Inspiration for innovation was drawn from sources such as publications, academia, sector events like ATC conferences, and private sector proposals, both from central and peripheral service areas.

Transitioning to new strategy

In the transition to a new approach and practices, the DGC has taken several measures to address previous barriers to innovation. The Road Act (Ley 37/2015) has explicitly included the promotion of research, development, and technological innovation as one of the aims of road policy. Circular Order 1/2022 on Declarations of Normative Exceptionality has been introduced to facilitate research, development, and technological innovation in the DGC. This order enables a centralized pathway within the Technical Directorate for the systematic testing of new solutions on roads and their margins. It aims to ensure the soundness of these innovations, enhance the understanding of road standards, promote coordination between central and territorial services, and share and verify

information in various fields, such as new materials, recycling, ITS, sensorisation, and Building Information Modelling (BIM).

The DGC is also actively focusing on progress in various areas to improve mobility and road management. This includes advancing in the field of Connected and Autonomous Vehicles (CAVs), using drones for asset inspection, and implementing digitalization strategies to enhance efficiency and simplify procedures both for citizens and internal operations. Sustainability is a key commitment, with efforts underway to calculate the carbon footprint, develop decarbonization plans, and promote energy-efficient strategies, including the installation of electric vehicle charging points.

Additionally, the DGC is emphasizing pavement sustainability, with revised road pavement standards to promote circular economy practices, the introduction of new asphalt mixes for efficiency, and the re-examination of pavement structural sections. The consideration of structural and surface condition indicators is being incorporated for informed decision-making in pavement management. Lastly, there is a significant promotion of cycling mobility, marked by the creation of a General Bicycle Office in 2021 and the development of a State Bicycle Strategy, reflecting the DGC's commitment to enhancing sustainable and eco-friendly transportation options.

New Approach to Innovation

The DGC has adopted a new approach to innovation, driven by several key factors. These change drivers include a reorientation toward mobility service delivery based on sustainability, digitalization, innovation, Big Data, and safety/security. The DGC has been responding to an intense and accelerated digitalization process in mobility and transport, the emergence of new technologies, services, and enterprise ecosystems, the development of new services impacting infrastructure, and the need to address environmental, technological, and innovation challenges alongside organizational and cultural shifts.

In its efforts to boost innovation capture and adoption, the DGC has shifted toward an "Open Innovation" approach. This includes identifying ten initial challenges within the organization, launching the DGC Public Procurement of Innovation, and conducting a preliminary market consultation that resulted in 555 proposals. In April 2023, the Sustainability and Innovation Directorate-General (SD-G) was established, with its main role being the leadership of the ongoing Innovation Plan. The DGC is also fostering a culture of innovation by designating a network of focal points and conducting dissemination activities like information days and webinars. To understand the current state of innovation, both within and outside the DGC, there is an ongoing consultation of internal and external stakeholders and a review of references and funding sources for innovative projects.

The ten initial challenges identified by the DGC encompass a wide range of road and transportation-related issues, from the design and optimization of road infrastructures to the deployment of autonomous vehicles and innovative execution of road projects. These challenges also encompass sustainability criteria for pavement construction, the use of AI technologies for road inspection, tunnel management modernization, pavement condition assessment, energy efficiency, road safety management, and protection measures for vulnerable road users and wildlife accidents. These challenges highlight the DGC's commitment to addressing a diverse set of issues through innovative approaches.

Public Procurement of Innovation Programme

The Public Procurement of Innovation Program (PPI) within the DGC is designed to support private innovation by motivating the market to address DGC's challenges. The program aims to foster cutting-edge processes and technologies for both current and future mobility needs. The main objective is to explore the capacity for private-public collaboration in developing innovative solutions that can enhance road management and transform travel experiences. The program commenced with a Preliminary Market Consultation, where the level of maturity and the state of innovative solutions were assessed. After this phase, 555 proposals were received, and among them, 209 high-interest proposals were selected. These selected proposals will lead to the development of 30 innovation projects, 60% of which are expected to be implemented in the short term. Additionally, 30 sub-challenges have been identified, and tender specifications are currently under development to facilitate the next steps of the program.

UGANDA - UGANDA NATIONAL ROADS AUTHORITY (UNRA)

Title of Presentation: UNRA Research, Development and Innovation Policy

Introduction

The Uganda National Roads Authority (UNRA) is pursuing a vision outlined in its Corporate Strategic Plan for 2020/21 to 2024/25, focusing on establishing a robust research and innovation program. This initiative is at the core of UNRA's mission, emphasizing the importance of research and innovation for continuous growth within the organization and the broader road sector. The primary goal is to create a dynamic environment conducive to ongoing development.

Policy Framework

To achieve this vision, UNRA has recognized the need for a comprehensive policy framework governing Research Development and Innovation (RDI) activities. The framework is designed to provide guidance for R&D planning, establish objectives, and ensure alignment with international best practices while optimizing resource utilization. Within this framework, specific elements are outlined, including situational analyses, establishment of baselines, creation of an Innovation and Technology Centre (ITC), and benchmarking of best practices. These actions aim to enhance UNRA's capabilities for informed decision-making, cost reduction, and the integration of environmentally sustainable materials and practices in road construction. The policy's effectiveness will be measured through key performance indicators, assessing the relevance of research findings and the adoption of innovative ideas in strategic areas. Ultimately, the policy is intended to position UNRA as centre of excellence in road and transport research.

Policy Principles

UNRA's policy principles for RDI establish a clear framework that integrates research standards and guidelines. These principles encompass diverse R&D activities, including in-house, externally contracted, and joint research, promoting a comprehensive approach to innovation. Innovation projects are designed to address 'foresight, insight, and hindsight' to ensure a forward-looking perspective and to enable lessons learned from past experience. The policy places a strong emphasis on applied research, striving for robust and rigorous results that can be integrated into decision-making processes, aiming for sustainable solutions and technologies.

Research Agenda

The Research Agenda, a key element of the policy, guides research activities based on UNRA's strategic needs and prioritised issues. It highlights the importance of regular reviews to maintain alignment with evolving objectives and encourages collaboration and knowledge sharing through a consultative and participatory approach. Prioritization of research activities will be informed by approved models like the Technology Tree, providing a structured approach to project selection.

Research Management

UNRA's policy principles also address Research Management, prioritizing technical progress and milestone achievements. Quality assessment focuses on the practical impact of research findings, aimed at addressing recurring challenges and proactively preventing future issues. Regarding Research-Related Intellectual Property (IP), the policy outlines a clear framework for IP ownership, allowing UNRA to safeguard its proprietary rights and promote collaboration and knowledge

exchange. This approach aims to foster innovation and establishment of mutually beneficial relationships, ensuring that technology and processes developed through in-house R&D remain owned or co-owned by UNRA.

Knowledge Cycle

The UNRA Knowledge Cycle represents a dynamic process focused on harnessing knowledge and experience for organizational growth. Within Knowledge Generation, UNRA actively supports diverse methods for capturing knowledge and experience. This includes facilitating easy access to knowledge for staff through electronic databases and libraries, with clear recognition criteria for staff contributing to knowledge creation, fostering a culture of knowledge-sharing.

Knowledge Management

The R&D Department at UNRA is responsible for Knowledge Management (KM), which is seen as a transformative tool to maintain the organization as a learning entity. It emphasizes the strategic importance of knowledge, enabling informed business operations based on insights and aligning with organizational learning principles.

Knowledge Dissemination ensures that research findings benefit all stakeholders. Additionally, UNRA actively supports collective learning and capacity building, leveraging the synergy between R&D, organizational learning, and implementation. UNRA's commitment to fostering innovation is demonstrated through its Innovation Think Tank, which encourages formation of Task Groups of voluntary communities who are passionate about a particular subject. UNRA may also invite external partners to its Task Groups to enrich the innovation process.

Fostering Innovation Culture

UNRA's policy outlines a structured approach to promoting RDI within the organisation. The Incentives Scheme is a critical component aimed at encouraging beneficial research activities. It seeks to foster a research culture among staff by providing incentives that stimulate innovative solutions within their respective roles. The policy highlights the importance of evaluating in-house research proposals and appropriately recognizing and rewarding them, reinforcing a commitment to excellence in research.

The Framework provides a structured approach to research activities. The R&D Department coordinates all research endeavours, ensuring a cohesive approach. Budget allocation follows the Research Agenda, aligning financial resources with strategic research priorities. Research calls are based on competitive selection, ensuring the highest quality projects are pursued. The R&D Department also proactively identifies, commissions, and supports in-house "think tank" or "incubation" teams to explore and develop innovative solutions. Research is conducted in line with relevant UNRA policies and guidelines, promoting consistency and compliance.

Monitoring and Evaluation

Monitoring and Evaluation (M&E) is a crucial element within the policy. The head of R&D will be responsible for monitoring and evaluating the performance of research, development, innovation, and knowledge management initiatives. UNRA is seeking to establish well-defined indicators to facilitate performance monitoring and evaluation, covering short, medium, and long-term impacts of RDI.

APPENDIX E. INNOVATION MANAGEMENT SYSTEMS

Innovation Management Systems (IMS) are software solutions to support and streamline an organisation's innovation activities. There are many commercial off-the-shelf solutions available. They typically support innovation by providing a single platform featuring planning, collaborative and analytical tools. See Figure 17. This appendix discusses what IMS can do and the benefits they can bring to a road or transport agency. It also discusses how an IMS can integrate into innovation process. Lastly it discusses what a roads organisation should consider when seeking to adopt an IMS.

Figure 17. How Innovation Management Systems Support the Process

Innovation management functions support the overall innovation process as follows.

Portfolio Management

Lage organisations with established cultures of innovation are likely to be pursuing many separate innovation ideas and projects. An IMS offers tools to track and monitor the progress of individual innovations, using this data to generate reports on the overall state and health of the innovation portfolio. Reports can include elements such as Return on Investment (ROI), distributions of projects across different development levels, or potential effects of the portfolio on important KPIs, with the content of these reports ultimately dependent on what data is collected and retain within the IMS.

Knowledge Sharing & Management

Knowledge management features are now common to many software suites, such as Microsoft SharePoint and Teams, or Google Workspace. Integration with these tools is commonly included in an IMS, where documents, data and analyses can be easily accessed and shared. Whilst IMS may not offer any greater functionality to businesses which have already adopted knowledge sharing and management software, they may offer improved efficiency for an organisation to confine its overall innovation system to a single platform.

Project Management

An IMS may feature project management features specifically designed to manage innovation. Like other IMS features described here, this is not a novel feature and most organisations will already have project management software. However, the value of incorporating project management feature into an IMS comes from integrating with other features of an IMS system. For example, the data input and collected as part of managing an innovation project could feed into the Portfolio Management aspect of an IMS allowing more detailed report generation, or avoiding the need to duplicate the same data across multiple systems.

Crowd Sourcing

Knowledge collection and collation is an important element of innovation culture, however collecting ideas for innovation and evaluations can be a time consuming and inefficient process. IMS may feature crowdsourcing tools that provide low cost and efficient methods of collecting information from a large user base. This could take the form of a digital ideas box, or a voting platform where staff and stakeholders can contribute their assessment of an innovation – supporting a 'bottom up' approach to innovation.

Ecosystem Engagement

As discussed above, an innovation culture should extend to the wider supply network of an roads organisation. An IMS provides the opportunity to invite and include the wider roads ecosystem within internal innovation processes such as innovation knowledge sharing or innovation project management, whilst maintaining separation between non-innovation business management tools which the wider ecosystem should not be able to access.

Access to Innovation and Forecasting Services

Some IMS systems feature integration to existing databases on innovation, technology or other forecasting features. This could enable a user to search for upcoming technologies to support the development of an innovation, or to analyse an innovation against wider trends while estimating its potential value to the organisation. Whilst these services can be found outside of an IMS, their integration within an IMS may enable more efficient working depending on an organisation's use case and innovation processes.

Gamification & Incentive Features

Gamification is an emerging concept where the elements of games which encourage and reward participants are repurposed in workplace applications. Some IMS systems feature gamification elements as part of their crowdsourcing elements to encourage wider participation among staff and stakeholders.

Automation

Automation applications within IMS are diverse, and serve to improve efficiency by taking simple tasks away from staff and actioning them within the IMS. Example of this include: detecting and merging duplicate innovation ideas; extracting tasks, milestones or targets from documents or correspondence; automating analysis of qualitative or quantitative data.

Identifying Innovations

The 'bottom up' process of collecting and collating innovative opportunities can be time- consuming for any organisation with a large number of staff or stakeholders. Digital suggestion boxes provided by an IMS can accelerate this process by automating the collection of data. This automation could extend to merging duplicate suggestions. Foresighting tools with an IMS can also support locating future opportunities or challenges which may require an organisation to innovate. Collaborative tools can support discussion and development of the innovation ideas collected, this can enable innovation ideas to evolve, and connect problems to solutions. This could be as simple as online discussion boards, but could also include tools to plan and host workshops or hackathons.

Evaluating Innovations

Evaluating innovation ideas typically comprising assessing the costs, benefits and risks associated with developing the idea further. An IMS can support these processes by enabling discussion of these aspects through collaborative tools. Voting tools can be used to evaluate both the importance of an innovation idea, but also the validate the costs, benefits and risks collected. Reporting and analytical tools support prioritisation and project programming by summarising and aggregating a portfolio of innovation ideas into a form suitable for selecting projects to take forward.

Developing Solutions

The development of an innovation follows a similar process to any project requiring project management, technical input and monitoring, though generally with greater uncertainty. Many IMSs offer integrated project management tools, the functionality of these tools may not extend beyond other established project management software and systems. However, using tools integrated into an IMS confers two important benefits.

Much data is collected during project management on tasks and progress. With this data, an IMS can offer more detailed reporting across a portfolio of ongoing innovation projects, for example it may incorporates data on progress through project development tasks to report on overall levels progress in the portfolio.

Collaboration with the wider ecosystem is an important part of a culture of innovation, however accepting external stakeholders into internal project and knowledge systems may be undesirable. A separate IMS project management system allows separation between strictly internal systems and those open to external collaborators.

Implementing Solutions

The core elements of a process to implement a newly developed innovation are change management and assessing whether the expected benefits of the innovation have been realised. This can be supported through tools that monitor adoption, and which collect feedback on the innovation and the benefits it has brought. This can support change management by highlighting issues with adoption, and feed into overall innovation portfolio reporting and improvement. As an IMS can span external stakeholders, these functions can be extended to the wider supply chain.

Overarching Processes

An IMS can also support processes which apply at every stage of the innovation development process. They can document knowledge developed at every stage of the development process, to prevent loss of insights and ensure they are widely available and not confined to silos. The wide range of data collected and analysis tools available support continuous improvement efforts, with the potential for automatic systems to highlight areas for improvement, for example if task duration estimations are biased towards under or over estimation. This data and analysis tools also support reporting on the state and composition of the overall innovation portfolio. Incentives and rewards for participation can be incorporated at each stage of the innovation process. This can be achieved by tracking which projects a person contributes too and the nature of the contribution, gamification tools can then automatically issue rewards. These could even be proportionate to the benefits realised from successful innovations.

Measuring the impact of innovations

There is quite a range or continuum of ability to measure. Some agencies have elaborate real-time systems available to employees, while most some spreadsheets for annual reporting to national government. As discussed in this report, measurement of impacts of innovations can be very complex, and a system to keep track of impacts of projects, especially as they are spread around the country, can itself save a lot of time and effort.

Adopting an Innovation Management System

Innovation Management Systems (IMS) can be complex pieces of software, and therefore it is important to careful evaluate your organisations needs against what an IMS can provide. An organisation should consider what innovation processes it currently uses when developing innovation to ensure an IMS meeting their needs. However, future needs and plans should be also be considered to ensure that any adopted IMS can meet current needs whilst supporting future expansion of innovation processes – something which may be accelerated by the presence of relevant features in an IMS even if they are not yet used in an organisation.

Due to their complexity, trialling an IMS prior to procurement is highly recommended, the Israel Netivei case study reported trialling a commercial IMS, however ultimately did not adopt it. Various organisations conduct research into IMSs and the companies which develop and supply them, services such as these provide an evidence-based starting point when searching for an IMS to trial. The information they provide includes both original research, and user insights. Some organisations offering such services include Gartner, Software Advice, Capterra, Trust Radius, and G2.

These organisations also allow filtering user reviews by company size to evaluate if the software is appropriate for a given Road Organisation’s size. Trials of IMSs should consider their effectiveness at streamlining and supporting an organisations innovation processes culture. Due to the nature of IMSs, there are other specific aspects to which attention should be paid during a trial, particularly integration with other existing systems such as project management system, knowledge management systems and, importantly, HR systems.

World Road Association (PIARC)

La Grande Arche, Paroi Sud, 5e étage, F-92055 La Défense cedex