EXCHANGING GLOBAL BEST PRACTICES IN ROAD TRANSPORTATION

U.S. Participation in PIARC 2016-2019 Cycle | April 2022

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16. Abstract

The World Road Association, known globally as PIARC, brings together experts from the road administrations of more than 120 governments, staff from private companies worldwide, and members of academia to focus on issues of technology transfer in road transportation. PIARC operates on a four-year cycle with a strategic plan focused on five themes. Delegates from around the world, including the United States, work within the PIARC Technical Committees to address specific road transportation issues and develop resources to guide improvements in practices, materials, and technologies. U.S. participation benefits the national transportation community by providing access to research, practices, and technologies from other countries that align with the strategic goals of the Federal Highway Administration (FHWA) in the areas of safety, infrastructure, and transformation

For the 2016-2019 cycle, FHWA's Executive Director was elected as a member of the Executive Committee and the Strategic Planning Commission. Active participation in the Executive Committee allows the United States to ensure that the management concepts and technical structures that were documented in the 2016–2019 Strategic Plan are executed as intended.

The impact of FHWA's participation in PIARC is far-reaching and involves the expansion of knowledge, sharing of outlooks and obstacles and making connections that strengthen the effectiveness of transportation community initiatives. During the 2016–2019 cycle, PIARC executed a more consistent production of interim products within the PIARC Technical Committees and the PIARC Task Forces, as well as from the deliberations and discussions of PIARC's corporate bodies. Key outcomes of participation include technical knowledge sharing, perspective, and context, expanded professional networks, and special projects program participation. Products from the cycle are shared nationally using FHWA, AASHTO, and TRB Technical Committee structures.

17. Key Words **World Road Congress, PIARC, Road Transport, Risk Management, Innovative Financing, Road Network Operations, Intelligent Transportation Systems, Winter Service, Sustainable Multimodality, Freight, Automated Vehicles, Asset Management, Bridges, Pavements, Tunnels, Adaptation**		18. Distribution Statement **No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.** http://www.ntis.gov	
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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The World Road Association, known globally as PIARC, serves as an international forum for knowledge exchange on a wide range of issues related to road transportation. The Association, which represents road administrations of 122 governments worldwide, focuses on development and technology transfer, in form of guidance documents, best practices, and decision tools on transportation-related policies and practices.

As a founding member, the United States shares a long history with the PIARC through active participation and partnerships at the World Road Congresses and International Winter Road Congresses as well as forums, task forces, and technical committees. The U.S. is represented by delegates from the Federal Highway Administration and American Association of State Highway Transportation Officials.

The PIARC operates on a four-year cycle and its operations are guided by a strategic plan developed for each cycle. The U.S. had an active participation in two PIARC-sponsored events: the 15th International Winter Road Congress, held in February 2018 in Gdańsk, Poland, and the XXVIth World Road Congress held in Abu Dhabi, United Arab Emirates, from October 6-10, 2019. In Abu Dhabi, The U.S. was represented by a delegation of 30 transportation professionals from the FHWA, State Departments of Transportation, academia, and the private sector.

For the 2016-2019 cycle, the PIARC's Plan of Activities, which are performed through its technical bodied, focused on five themes—*Management and Finance, Access and Mobility, Safety, Infrastructure, and Climate Change,* and *Environment and Disasters.* The U.S. delegation has had technical representation in 17 PIARC Technical Committees and four PIARC Task Forces, which accounted for more than 75 percent of the Association's technical bodies.

Through this four-year cycle, the U.S. delegates played a significant role in the development of 46 technical reports, including 16 flagship products that focused on a range of issues within these themes. This report documents the outcomes of the U.S. participation in PIARC activities during the 2016-2019 cycle. Key outcomes of the U.S. participation in PIARC's Technical Committees and Task Forces include:

Technical Knowledge Sharing:

U.S. delegates were exposed to emerging ideas and innovations from cutting-edge thinkers from countries that lead in specific technical topics. U.S. delegates supported the international road transportation community through knowledge transfer when the U.S. had specific technical expertise.

Perspective and Context:

U.S. delegates were exposed to problems faced by the road transportation community worldwide. Their participation allows them opportunities to work collaboratively on solutions to common issues.

Expanded Professional Networks:

U.S. delegates built professional relationships with professionals they would otherwise not meet. The PIARC participants were often involved in day-to-day transportation operations and are an excellent source of technical information.

Special Projects Program:

The PIARC established the Special Projects Program to support projects outside the rubric of its Strategic Plan to more quickly complete smaller bodies of work to address critical issues. United States involvement in these Special Projects aimed to fill in knowledge gaps and obtain information on emerging road-related policies and practices in support of FHWA's priorities.

Infrastructure **Safety** **Transformation**

The accomplishments of the U.S. delegation, including the flagship products and knowledge gain, in the 2016-2019 cycle align with FHWA's goals and objectives for the U.S. transportation industry in areas of interest, which include Safety, Infrastructure, and Transformation. This report presents a description of the PIARC flagship products, their alignment to U.S. areas of interest, and the benefits to the domestic transportation community. The findings of this report were based on a series of discussions held with the U.S. delegation as well as the mapping of flagship products with areas of interest.

Multiple work products were prepared to document U.S. leadership, participation, and takeaways from involvement in the PIARC 20-16-2019 cycle and the 2019 World Road Congress. The products from this cycle will be disseminated to state and local agencies, and national public, private, and academic audiences via presentations and other communication channels of the FHWA, AASHTO, and Transportation Research Board (TRB).

ABOUT PIARC

Overview

The World Road Association, known globally as PIARC, brings together experts from the road administrations of more than 120 governments, staff from private companies worldwide, and members of academia to focus on issues of technology transfer in road transportation.

PIARC's highest governing body is the Council. It is composed of delegations from member states, each led by a first delegate. The Council elects the officers and the members of the Executive Committee. Composed of roughly 30 representatives elected by the Council every four years, the Executive Committee manages the PIARC. It is supported by Commissions on Finance, Communications, and Strategic Planning (SPC) and the General Secretariat. The SPC, in which FHWA is involved, is responsible for PIARC's formal strategic planning process; it oversees the development and implementation of the work program.

2016–2019 Four-Year Cycle

PIARC operates on a four-year cycle and its operations are guided by a strategic plan developed for each cycle. The 2016-2019 strategic plan focused on five themes—Management and Finance, Access and Mobility, Safety, Infrastructure and Climate Change, Environment and Disasters. Delegates from around the world, including the United States, work within PIARC Technical Committees to address specific road transportation issues and develop resources to guide improvements in processes, materials, tools, and technologies in road transportation.





ABOUT U.S. PARTICIPATION IN PIARC

Participation in PIARC affords the United States an opportunity to exert valuable exchanges in the global discussion on key road-related issues. This involvement is also an effective channel for communicating U.S. developments to the world. U.S. participation also benefits the national transportation community by providing access to research and practices from other countries that align with the Federal Highway Administration (FHWA) and state and local transportation agencies' interests.

Leadership

In the 2016-2019 cycle, just as with the previous two PIARC cycles (2008–2011, 2012–2015), the U.S. delegation, including FHWA staff, has had technical representation in more than 75 percent of the PIARC's Technical Committees. Appointment of FHWA representatives to the PIARC Technical Committees was made based on FHWA program priorities. For the 2016-2019 cycle, FHWA's Executive Director was elected as a member of the Executive Committee and the SPC. Active participation in the Executive Committee allowed the United States to ensure that the management concepts and technical structures that were documented in the 2016–2019 Strategic Plan were executed as intended. This level of commitment of U.S. representatives continues into the 2020–2023 cycle.

Participation Strategies, Events, and Information Dissemination

U.S. delegates actively participated in the 17 PIARC Technical Committees (see Table 1). A summary of their work products is included in ***Work Products & Knowledge Transfer*** at the end of this report. Through PIARC Technical Committee participation, U.S. delegates were active in the development of products that advanced the global transportation industry. Products from each cycle were disseminated to state and local agencies, and national public, private, and academic audiences via presentations from communication channels of the FHWA, American Association of State Highway Officials (AASHTO), and Transportation Research Board (TRB).

PIARC 2016–2019 Cycle

17

STRATEGIC TECHNICAL COMMITTEES

4

TECHNICAL TASK FORCES

46

PUBLISHED TECHNICAL REPORTS

U.S. PIARC Participation in the 2016-2019 Cycle

30

TECHNICAL COMMITTEE MEMBERS

1

TASK FORCE CHAIR

TABLE 1. **U.S. Delegate Participation in 2016-2019 Cycle Committees**

Infrastructure | Safety | Transformation

FHWA/USDOT STRATEGIC THEME RELEVANCE	PIARC COMMITTEE & STRATEGIC THEME (ST)	U.S. DELEGATE, ORGANIZATIONAL AFFILIATION & ROLE
ORGANIZATIONAL EXCELLENCE	**STA Committee A.1** Performance of Transport Administrations	**Christos Xenophontos,** *Rhode Island Department of Transportation, Assistant Director* **Francine Shaw-Whitson,** *Federal Highway Administration, Transportation Performance Management Programs, Team Leader*
INFRASTRUCTURE	**STA Committee A.2** Road Transport System Economics and Social Development	**David Luskin,** *Federal Highway Administration, Economist, Investment & Economic Analysis Team*
TRANSFORMATION	**STA Committee A.3** Risk Management	**Firas Ibrahim,** *Federal Highway Administration, Stewardship/Oversight Team Leader* **Jean Wallace,** *Minnesota Department of Transportation, Assistant Modal Planning & Program Management Division Director*
TRANSFORMATION	**STA Task Force A.1** Innovative Financing	**Michael Patterson,** *Oklahoma Department of Transportation, Executive Director*
ORGANIZATIONAL EXCELLENCE	**STA Task Force A.2** Coordination between National and Sub-National Authorities	**King Gee,** *American Association of State Highway and Transportation Officials, Director of Engineering and Technical Services*
TRANSFORMATION	**STB Committee B.1** Road Network Operations / Intelligent Transportation Systems	**Valerie Briggs,** *Federal Highway Administration, Director, Office of Transportation Management* **Galen McGill,** *Oregon Department of Transportation, ITS Manager*
CLIMATE AND SUSTAINABILITY	**STB Committee B.2** Winter Service	**Gabriel Guevara,** *Federal Highway Administration, Road Weather Team* **Steve Lund,** *Minnesota DOT, Principal State Maintenance Engineer*
CLIMATE AND SUSTAINABILITY	**STB Committee B.3** Sustainable Multimodality in Urban Areas	**Harlan Miller,** *Federal Highway Administration, Planning Engineer*
ECONOMIC GROWTH	**STB Committee B.4** Freight Transport	**Tiffany Julien,** *Federal Highway Administration, Office of Freight Management and Operations, Program Delivery Team* **Lori Porreca,** *Federal Highway Administration IDAHO (HDA-ID), Community Planner*
TRANSFORMATION	**STB Task Force B.2 (NEW)** Automated Vehicles: challenges and opportunities for road operators and road authorities	**John Harding,** *Federal Highway Administration, Team Leader, Connected/Automated Vehicles and Emerging Technologies*

FHWA/USDOT STRATEGIC THEME RELEVANCE	PIARC COMMITTEE & STRATEGIC THEME (ST)	U.S. DELEGATE, ORGANIZATIONAL AFFILIATION & ROLE
SAFETY	**STC Committee C.1** National Road Safety Policies and Programs	**John Milton,** *Washington State Department of Transportation, Director of Quality Assurance and Transportation System Safety* **Karen Scurry,** *Federal Highway Administration, Traffic Operations and Safety Engineer* **Mike Griffith,** *Federal Highway Administration, Director, Office of Safety Technology*
TRANSFORMATION	**STD Committee D.1** Asset Management	**Gerardo Flintsch,** *Virginia Tech Transportation Institute, Director, Center for Sustainable Transportation Infrastructure* **Derek Constable,** *Federal Highway Administration, Senior Bridge Management Engineer*
CLIMATE AND SUSTAINABILITY	**STD Committee D.2** Pavements	**Gina Ahlstrom,** *Federal Highway Administration, Pavement Design & Analysis, Team leader* **Nadarajah Sivaneswaran,** *Federal Highway Administration, Turner Fairbank Highway Research Center Highway Research Engineer, Infrastructure Analysis and Construction Team*
TRANSFORMATION	**STD Committee D.3** Bridges	**Joseph Hartman,** *Federal Highway Administration, Director, Office of Bridges and Structures* **Scot Becker,** *Wisconsin Department of Transportation, Director of Bureau of Structures/State Bridge Engineer*
EQUITY	**STD Committee D.4** Rural Roads and Earthworks	**Jennifer Nicks,** *Federal Highway Administration, Turner Fairbank Highway Research Center, Research Geotechnical Engineer, Bridge and Foundation Engineering Team*
TRANSFORMATION	**STD Committee D.5** Road Tunnels Operations	**William Bergeson,** *Federal Highway Administration, Senior Tunnel Engineer* **Bijan Khaleghi,** *Washington Department of Transportation, Bridge Design Engineer*
CLIMATE AND SUSTAINABILITY	**STE Committee E.1** Adaptation Strategies / Resiliency	**April Marchese,** *Federal Highway Administration, Director, Office of Natural and Human Environment*
CLIMATE AND SUSTAINABILITY	**STE Committee E.3** Disaster Management	**Herby Lissade,** *California Department of Transportation (Caltrans), Chief, Office of Emergency Management*

In addition, U.S. delegates participated in the two PIARC-sponsored Congresses (a standing feature of each four-year cycle): The World Road Congress and the International Winter Road Congress. The goal of these Congresses, held in member countries, is to enable PIARC members to share techniques and experiences in the field of road transportation and to showcase the key accomplishments and findings of their Technical Committees. The 2016-2019 Cycle included:

- **The 15th International Winter Road Congress, held in February 2018 in Gdańsk, Poland**
  The event's theme was "Providing a Safe and Sustainable Winter Road Service."
- **The 26th World Road Congress, held in October 2019 in Abu Dhabi, United Arab Emirates**
  More than 5,000 delegates from 145 countries participated in this event. The U.S. delegation comprised of representatives from the FHWA, AASHTO, TRB, state Departments of Transportation (DOT), academia, and private sector firms. Representatives participated in nearly two dozen sessions and workshops and presented 19 papers focused on progressing timely, multimodal transportation goals in the areas of safety, infrastructure, and transformation, which were compiled into the *U.S. Participation in World Road Congress Summary Report* (FHWA, 2021).

As part of their information dissemination and technology transfer activities, U.S. delegates of the 2016-2019 cycle delivered presentations on PIARC's Technical Committee activities to several AASHTO and TRB committees, including:

- AASHTO Committee on Bridges and Structures.
- AASHTO Committee on Maintenance.
- AASHTO Committee on Performance-Based Management TRB/AASHTO/Aurora/Pooled Fund.
- National Cooperative Highway Research Program.
- TRB Management and Productivity Committee.
- TRB Performance Measurement Committee.
- TRB Regional Transportation System Operations Committee.
- TRB Regional Freeway Operations Committee.
- TRB Transportation Asset Management.

HOW PARTICIPATION IN PIARC ADVANCES FHWA AREAS OF INTEREST

Aligning PIARC Plan of Activities with FHWA's Areas of Interest

FHWA's areas of interest align with the U.S. Department of Transportation (USDOT) Strategic Plan and reflects the FHWA's policy priorities and programs in three high-level areas of focus.

SAFETY	INFRASTRUCTURE	TRANSFORMATION
Make our transportation system safer for all people. Work toward a future where transportation-related serious injuries and fatalities are eliminated.	**Support and engage people and communities to promote safe, affordable, accessible, and multimodal access to opportunities and services while reducing transportation-related disparities, adverse community impacts, and health effects.**	**Design for the future. Invest in purpose-driven research and innovation to meet the challenge of the present and modernize a transportation system of the future that serves everyone today, and in the decades to come.**

PIARC's technical products, which were produced in the 2016–2019 cycle, are organized under each of the FHWA's focus areas. The following sections present a brief overview of how these technical products relate to and advance these areas of interest.

SAFETY: Implementation-Related Practices and Tools

FHWA is committed to the vision of zero deaths and serious injuries on the nation's roadways. The safety goal seeks to make its transportation system safer for all: to prioritize safety and public health using informed decision-making and data-driven approaches, working toward a future where transportation-related serious injuries and fatalities are eliminated. The current crash statistics are alarming: the United States lost 37,461 lives on its roads in 2016, an increase of 5.6 percent from 2015. This is a compelling reason to learn how other countries face road safety challenges. FHWA is encouraged to continuously enhance and sustain a culture of safety, and helps stakeholders do the same. Many of the proven strategies from other countries align with the National Safety Council's "Road to Zero" and global plan for "Decade of Action for Road Safety" initiatives. The United States can gather knowledge and practices from peer nations and bring it home for implementation. For example, the Safe System approach came from Europe, Australia, and New Zealand and is gaining traction in the domestic transportation community.

Likewise, many countries look to U.S. innovations and best practices to aid their transportation industries. Participation in the PIARC provides a practitioner-focused forum to better understand the challenges and solutions of peer nations and share findings with the global community.

Implementation of National Safe System Policies: A Challenge

The report "National Safety System Policies and Implementation" includes insights from U.S. authors Erin Kenley and Karen Scurry of the FHWA. This document includes survey responses from 31 national government agencies regarding their assessment of their respective practices on road infrastructure safety and the Safe System approach. Not all governments surveyed are members of the PIARC organization.

Because the countries surveyed represent

a broad cross section of geographies and financial means, the report focuses primarily on infrastructure strategies with only limited review of institutional or managerial actions. A successful Safe System approach encompasses much more than infrastructure improvements, encompassing agency and governmental policies and procedures, as well as support from law enforcement and educational resources.

Although general knowledge and awareness of Safe Systems is high, most respondents still struggle with implementing a Safe System approach. The United States, despite a comparatively high income, shares some of the same challenges as other countries, of high, upper middle and low income. Some challenges are staffing shortages, low detailed crash data, and low condition or system performance information. One of the hallmarks of the approach is setting road safety targets. There are five federally mandated reporting measures in the United States; however, each state is tasked with setting its own targets, and there is a wide variety of success with regards to meeting these goals.

Investments in road safety infrastructure are prioritized in multiple ways, with benefit-cost ratios being the most common evaluation technique. Other methods include the potential for improvement, cost-effectiveness, and crash rates. The approaches used to calculate the benefits vary with more statistically robust—and data intensive—methods gaining prevalence.

This report is noteworthy as it demonstrates that high-income countries still face challenges in reducing fatal and serious crashes on their roadways.

Road Safety Manual[1]

The ***Road Safety Manual*** aims at providing clear and accessible information on the effective management of road safety infrastructure. Different countries and agencies, experiencing varying needs and at different stages regarding the maturity of their networks may find certain sections more pertinent than others. The manual's current edition—its third—builds on prior knowledge and updates the body of knowledge that has advanced since the first edition was made available. Notably, over 40 new case studies have been added from countries around the world.

This document was updated by the PIARC Technical Committee C.1 National Road Safety Polices and Programs (2016–2019). Working Groups 1 with support from Working Group 2. John Milton, of the Washington State Department of Transportation, served as co-leader of Working Group 1 and as an author and editor. He provided final review and quality control for the English language version. Through Mr. Milton's contributions, the technical expertise of the United States is evident.

The manual is aligned with several key pillars of the United Nations Decade of Action for Road Safety (2011–2020), notably the first (Road Safety Management), the second (Safer Roads and Mobility), and fourth (Safer Road Users) pillars.

The manual is focused on low- and middle-income countries (LMIC) and how safety issues are being addressed by practitioners in these countries. Higher-income countries (HIC), including the United States, will still benefit from these findings as many of the issues have not been fully resolved on all road networks. Additionally, techniques and methods used by countries and agencies with fewer resources are valuable guidance for smaller agencies within HICs that may not have the same funding or technology available as their state and federal counterparts.

The actionable guidance in ***Part 2: Road Safety Management and Part 3: Safe Planning, Design, Operation & Use of Road Network*** is relevant to public and private road controlling authorities, engineers, and researchers aiming to reduce the frequency and severity of crashes on transportation networks. The United States found value in including the human factor in road design and operation. PIARC documents and practices have been incorporated into National Cooperative Highway Research Council projects as necessary reference and where appropriate to incorporate this knowledge into U.S. practice through associated training and pilot studies.

[1] https://roadsafety.piarc.org/en

Most local agencies look to state and federal guidance for best practices on road safety, and FHWA's involvement with PIARC could be a path to disseminate this international body of knowledge to U.S. practitioners.

Review of Global Road Safety Audit Guidelines – With Specific Consideration for Low- and Middle-Income Countries [2]

Many countries have published guidance documents to help practitioners facilitate Road Safety Audits or Assessments (RSA). This guide is aimed at audiences in LMICs; however, it notes that while the approach in the United States may differ from other countries, the general layout of their respective manuals and the process involved in assessments are similar.

Many smaller agencies in the United States, as well as several large ones, deal with similar challenges to LMICs when implementing RSAs. Agencies experience staffing challenges, including low numbers of experienced or available auditors and the capacity of staff responsible for transportation networks to review and implement recommendations arising from an RSA report. Additionally, the implementation of RSA is affected by factors at the crash site such as a mix of traffic and primary-crash types, vehicle conditions, driver compliance with rules and regulations

Unmanned Aerial Systems (UAS), or drones, have been used to augment or supplement traditional data gathering methods or assess infrastructure when the health and welfare of human employees may be at risk. This report presents five case studies to demonstrate the applications of UAS under five topics: highway construction, inspection and asset monitoring, emergency response, traffic monitoring, mapping, and law enforcement.

Of the five case studies, three of them are based in the United States. Several U.S. states, federal agencies, universities, and contractors shared their experiences using UASs for a variety of transportation assessments, including highway monitoring and construction, traffic management, and natural disaster response.

This report highlights the potential of UAS applications in minimizing safety risks associated with work zone management, bridge and automatic pavement inspection, and monitoring of unpaved/gravel road conditions. The report also demonstrated the applications of UAS high resolution imagery in crash scene reconstruction. More information on the PIARC's special report on the UAS applications is discussed under the ***Transformation*** section.

Road Safety Evaluations Based on Human Factors Method[3]

This guide helps instruct practitioners in evaluating road safety along operational facilities, which is often complicated by active traffic operations. In the United States, many roadways, especially in urban areas, pose challenges related to the density and quantity of vehicles.

Road safety screening uses a variety of techniques, including crash data analysis, review of locations with high crash concentrations, and proactive assessment using Human Factors' principles in road design. The benefit of this proactive approach helps the practitioners in identifying concerns and deficiencies in roadway infrastructure and select countermeasures to improve roadway safety at the network level.

The Role of Road Engineering in Combating Driver Distraction and Fatigue Road Safety Risks[4]

Driver distraction and fatigue are not unique to LMICs or HICs, though distraction may be of greater concern in HICs, where more advanced vehicles include technologies such as touch screens or cellular phone integration.

Engineers consider driver limitations and reaction time when designing transportation infrastructure to help lower the risk of a crash, by comprehending a change in conditions and taking

[2] https://www.piarc.org/en/order-library/31994-en-Review%20of%20Global%20Road%20SafetyAudit%20Guidelines%20%E2%80%93%20With%20Specific%20Consideration%20for%20Low-%20and%20Middle-IncomeCountries
[3] https://www.piarc.org/en/order-library/31358-en-Road%20Safety%20Evaluations%C2%A0Based%20on%20Human%20Factors%20Method
[4] https://www.piarc.org/en/order-library/25760-en-The%20Role%20of%20Road%20Engineering%20in%20Combatting%20Driver%20Distraction%20and%20Fatigue%20Road%20Safety%20Risks

an appropriate action if warranted. Most of the literature on driver distraction and fatigue has been focused on education and enforcement strategies aimed at discouraging negative behaviors.

Vulnerable Road Users: Diagnosis of Design and Operational Safety Problems and Potential Countermeasures[5]

Vulnerable road users (VRUs) include pedestrians, bicyclists, motorcyclists, and light duty farm vehicles or animal drawn vehicles. VRUs are not or relatively inadequately protected than passenger vehicle occupants, and therefore, at a greater risk of a conflict with motorized transport. The safety of VRUs is a worldwide concern. The United States has greater reliance on the use of motor vehicles than many other countries; however, there are significant populations where nonmotorized transportation is critical, including in urban core areas, low-income areas, and in minority, American Indian, and Alaskan Native areas. Additionally, nonmotorized fatalities have been increasing in many parts of the United States. In the U.S., per the NHTSA statistics, traffic crashes cause more than 7000 pedestrian and bicyclist fatalities and over 100,000 pedestrian injuries annually. Similarly, with approximately 5000 motorcycle fatalities occurring annually nationwide, the motorcyclists are 29 times more likely to be killed than passenger vehicle occupants based on the comparison of vehicle miles of travel.

The number of nonmotorized fatalities and serious injuries is a safety performance measure tracked by states and FHWA. Identification of concerns and countermeasures for vulnerable road users is of significance to U.S. entities. Placing the emphasis on the VRU safety, this report presents a catalogue of various safety-related design deficiencies, countermeasures, and checklists for road safety audits. The catalogue can serve as a useful tool to incorporate VRU safety in highway design and road safety audits.

Prevention and Mitigation of Tunnel-Related Collisions[6]

Safety is one of the critical requirements of tunnel design and operations. Tunnel operators implement many safety measures to prevent, control, and mitigate the consequences of safety hazards, such as fire, hazardous materials, and vehicle collisions. Because of the enclosed space, a specific characteristic of a tunnel could play a role in the cause (e.g., insufficient lighting at the entrance of a tunnel) or the effect (e.g., a vehicle colliding at a jet fan) of a collision. This report presents guidance on the prevention and mitigation of tunnel-related collisions.

The report "Prevention and Mitigation of Tunnel-Related Collisions" presents a summary review of various types of tunnel-related collisions, possible causes contributing to collisions, and the potential role of tunnel characteristics in the cause and effect of collisions. The report also presents various prevention and mitigation measures related to tunnel design, maintenance, and operations. The investment needs, safety effectiveness, and life cycle costs of the measures are also discussed.

In the United States, hundreds of vehicular collisions have occurred in tunnels over the last decade; however, the lack of comprehensive information on the statistics, location, nature, and severity of collisions has been a challenge to appropriate prevention and mitigation measures. Following the recommendation of the National Transportation Safety Board, the United States has been developing a guidance to facilitate a data-driven decision framework for prevention and mitigation of tunnel-related collisions.

In summary, the tunnel programs in Europe, Australia, and other HIC countries tend to be more mature than in the United States, and these programs provide a terrific opportunity for knowledge exchange. The United States can investigate the approaches described in these reports to advance the practice in improving tunnel safety, ventilation, and emission control. The progress that the United

[5] https://www.piarc.org/en/order-library/27282-en-Vulnerable%20road%20users:%20Diagnosis%20of%20design%20and%20operational%20safety%20problems%20and%20potential%20countermeasures
[6] https://www.piarc.org/en/order-library/30243-en-Prevention%20and%20Mitigation%20of%20Tunnel-Related%20Collisions.

States has made in the integration of FFFS with EVS is an example of how its involvement with PIARC and follow-up Global Benchmarking studies have contributed to the advancement of practice maturity.

SUSTAINABLE INFRASTRUCTURE: Implementation- Practices and Tools

In the United States, transportation infrastructure plays a central role in America's economic recovery. Road infrastructure is meant to support and engage people and communities to provide safe, affordable, accessible, and multimodal access to opportunities and services, reduce transportation-related disparities, and minimize adverse impacts to community and public health. Participation in PIARC technical activities benefits the wider transportation community in advancing the state of the practice and adopting state of the art technologies domestically in many areas, including the life cycle management of tunnels, road-related data collection and analysis technologies, sustainable multi-modal transit centers, and evaluation tools for green infrastructure. Likewise, many countries would benefit from the U.S. guidance on infrastructure practices, such as snow and ice removal, infrastructure resilience in response to sea-level rise and natural disasters, advanced early warning and remote sensing systems, and highway bridge safety.

Innovative Approaches to Asset Management[7]

A series of the International Organization for Standardization (ISO) 55000 standards provides a structured framework to guide the implementation or enhancement of the transportation asset management (TAM) practice. The ISO 55000 framework encapsulates a coordinated set of risk-based, information-driven, planning, and decision-making processes to optimize the service delivery objectives of an organization and realize value from assets. The level of sophistication and versatility of the TAM practice depends on the digital infrastructure to collect, record, process, model, and analyze data. Leveraging on the ISO 55000 framework and digital infrastructure, the PIARC Technical Committee D.1. Asset Management explored recent technological advancements and methodologies to identify a wide range of innovations to improve TAM practice.

The PIARC Technical Committee D.1 on Asset Management identified emerging techniques to collect and update network and project level data such as using lidar technologies, drones, robots for bridge inspection, 3D ground penetrating radar, high-speed laser dynamic deflectometers, accelerometers within smartphones and autonomous vehicles, and crowdsourcing of data using social media. In addition to condition-focused asset management, the D1 Committee provided guidance on collection and utilization of performance aspects, including traffic congestion, accident, noise, and hazard data in making road management and improvement decisions. The report also highlighted the applications of probabilistic methods to account for natural variability of influencing factors in deterioration modeling. The PIARC Technical Committee D.1 placed a significant focus on two aspects: (1) building information models, related data technologies, and strategies to facilitate digital transformation in the road transport sector; and (2) integral asset management for improved coordination and optimized decision-making in a constrained funding environment that balances various asset type and stakeholder needs.

The United States is adopting most of the innovative approaches described in this report. All 50 states and many local agencies have described the TAM approaches in their risk-based TAM plans. Under the leadership of FHWA and AASHTO, the transportation community is advancing the innovative approaches described in research through implementation in all aspects of TAM, including expanding the inventory to nontraditional assets, deploying drones in asset inspections, integrating construction and maintenance data, developing sophisticated

[7] https://www.piarc.org/en/order-library/31221-en-Innovative%20Approaches%20to%20Asset%20Management.

analytical techniques and models, and incorporating risk management into TAM decision-making.

The United States, as well as other countries in various stages of development, has an abundance of data that provides a common challenge on how to make more effective decision for all and across asset types. New transportation policies are being explored to address safety and maintenance while accommodating emerging technologies.

Resilience: Refinement of PIARC's International Climate Change Adaptation Framework for Road Infrastructure[8] and Adaptation Methodologies and Strategies to Increase the Resilience of Roads to Climate Change – Case Study Approach[9]

In 2015, the PIARC Technical Committee E.1 Adaptation Strategies and Resiliency developed the "International Climate Change Adaptation Framework for Roads" to provide guidance to transportation agencies on climate resilience. This framework provided a consistent approach to impact analysis, risk management, adaptation planning, and decision-making. Following this work, the PIARC Technical Committee E.1 commissioned two internal working groups to review 57 collected case studies and experiences and develop a state-of-the-art case study analysis of adaptation strategies. The efforts of the Technical Committee's working groups culminated in refinements to the 2015 edition of the adaptation framework.

The climate change adaptation framework is structured using a four-stage approach: (1) to establish scope, goals, and plans for evaluating climate effects and for identifying vulnerable locations and operations; (2) to assess impact probability and severity, develop risk scores, and establish a risk register; (3) to identify, select, and prioritize adaptation responses and strategies, and develop an adaptation action plan; and (4) to integrate assessment findings into decision-making decisions, communication plans, and other planning and operational procedures. To supplement the framework, PIARC Technical Committee E.1 which developed a detailed methodology that breaks down each stage into finite steps and supports each with case study examples.

The PIARC reports provide the implementation lessons from the 2015 pilot framework (in Mexico and Australia), as well as feedback from member countries who participated in several workshops held during this period. These reports represent the comprehensive synthesis of state-of-the-art knowledge on climate change adaptation for roads.

The environmental impact of extreme weather (excessive heat, increased precipitation, etc.) on transportation systems is a focus for USDOT and state DOTs. The United States has invested heavily in the development and implementation of climate resilience framework for over a decade. FHWA has released a third edition of its book the ***Vulnerability Assessment and Adaptation Framework,*** which is comparable to the PIARC framework. The Vulnerability Assessment and Adaptation Framework, provides guidance to transportation agencies in conducting vulnerability assessments of transportation infrastructure systems. Since 2010, in partnership with FHWA, state and local transportation agencies have conducted 47 pilots and numerous case studies to demonstrate and deploy adaptation solutions to improve resilience. Furthermore, many state and local agencies, including those in California and Massachusetts, have embarked on a multiyear effort to integrate resilience considerations in transportation practice.

Reducing the Life Cycle Carbon Footprint of Pavements[10] and Green Paving Solutions and Sustainable Pavement Materials[11]

To reduce the transportation's share of the carbon footprint, roadway agencies across the world are advancing toward mainstreaming many green solutions to roadway construction. The

[8] https://www.piarc.org/en/order-library/31390-en-Refinement%20of%20PIARC%E2%80%99s%20International%20Climate%20Change%20Adaptation%20Framework%20for%20Road%20Infrastructure
[9] https://www.piarc.org/en/order-library/31335-en-Adaptation%20Methodologies%20and%20Strategies%20to%20Increase%20the%20Resilience%20of%20Roads%20to%20Climate%20Change%20%E2%80%93%20Case%20Study%20Approach
[10] https://www.piarc.org/en/order-library/36607-en-Reducing%20The%20Life%20Cycle%20Carbon%20Footprint%20Of%20Pavements
[11] https://www.piarc.org/en/order-library/31415-en-Green%20Paving%20Solutions%20and%20Sustainable%20Pavement%20Materials

PIARC Technical Committee D.2 Road Pavements published two reports: "Reducing the Life Cycle Carbon Footprint of Pavements" and "Green Paving Solutions and Sustainable Pavement Materials." These reports summarized the state-of-the practice applications of various sustainable techniques that build on the principles of minimal resource use, longer life, reduced waste, and increased use of reused, recycled, and secondary materials. These reports present findings based on two surveys that received responses from more than 30 countries.

The PIARC Technical Committee D.2 conducted a critical review of various carbon footprint tools, including Pavement Life-cycle Assessment Tool for Environmental and Economic Effects (PaLATE), Highway Agency Carbon Calculator Tool (HACCT), ASphalt Pavement Embodied Carbon Tool (asPECT), GreenHouse Gas Calculator (GHGC), Calculator for Harmonised Assessment and Normalisation of Greenhouse gas Emissions for Roads (CHANGER), Système d'Evaluation des Variantes Environnementales (SEVE), DUurzaam BOuwen CALCulator (DUBOCALC) Energi och Koldioxid i Asfaltproduktion (EKA), and ECOcomparateur Route Construction Entretien (ECORCE). The review evaluates each tool's suitability for sustainability assessment of pavement technologies and interprets their inputs.

The PIARC Technical Committee D.2 presents information on green technologies as they apply to various pavement life cycle phases, from material selection and structural design to end-of-life decisions. These reports reviewed proven and emerging technologies, including reclaimed materials, biofuels, blended cements, plastic roads, long-life designs, two-layer concrete, dry stockpiles for asphalt production, warm mix asphalt, intelligent compaction, effective construction and maintenance practices. They also deal with incorporating sustainability criteria in contracting and procurement, recycling at the end-of-life, and associated tools.

The PIARC Technical Committee D.2 places an additional focus on green public procurement. Citing the Netherlands as a case study example, the report discusses how environmental considerations are incorporated into procurement decisions. In the Netherlands, potential environmental impacts are assessed using a life cycle assessment tool, DuboCalc, and the associated abatement costs are monetized. This monetary equivalent of environmental impacts is then considered in bidding decisions. As the contracts are performance based, the contractors and suppliers are required to submit environmental product declarations to a national database.

FHWA published a report of Sustainable Paving Practices, which was the first international report of this type. Upon learning of different case study successes across the world, it became apparent that the United States could learn from others on resiliency. For example, in the United States there is an emerging interest in composite pavements and developing an assessment tool for environmental impacts for materials.

State of the Art in Monitoring Road Condition and Road / Vehicle Interaction[12]

As an extension of the 2015 Report "State of the Art in Monitoring Road Condition," the PIARC Technical Committee D.2 Road Pavements provided an update with a synthesis of recent research and case studies from around the world on pavement functional and structural condition indicators. This report provides measurement methods and indicators for 10 parameters that characterize pavement condition under four categories: surface evenness, vehicle/road interaction, surface defects, structural condition.

This report also presents a synthesis on the state-of-the-art technologies on the collection of road condition data. This report introduces a "floating car data" concept that leverages the proliferation of sensors in cars and smartphones to collect probe-based, crowd-sourced data on pavement condition. This report identifies the following

[12] https://www.piarc.org/en/order-library/30891-en-State%20of%20the%20Art%20in%20Monitoring%20Road%20Condition%20and%20Road%20/%20Vehicle%20Interaction.

technologies: Tomorrow's Road Infrastructure Monitoring and Management, Sensors on Vehicles, Mobile Observation Methods for Road Maintenance Assessments, Intelligent Roads, Connected Vehicle, Smartphone-based Road Monitoring, TotalPave, RoadBounce, Roadroid, and RoadLabPro.

In the United States, transportation agencies collect copious roadway condition data to make effective pavement management decisions. Transportation agencies have significant experience in deploying myriad technologies, such as friction testers, ground-penetrating radar, infrared thermography, and lidar in-pavement condition measurement. Under the leadership of FHWA, transportation agencies are working toward operationalizing emerging technologies, such as traffic speed deflectometers. However, European countries are more advanced than the United States in the development and deployment of in-vehicle sensor technologies for pavement condition measurement. The work of other countries will inform and supplement many research and development efforts that are underway in the United States.

Large Underground Interconnected Infrastructure[13]

Two tunnels in Washington State were added to this manual during its update: Interstate 90 Mount Baker Tunnel and State Route 99 Alaskan Way Viaduct Tunnel through Seattle. This document identifies and analyzes existing and future underground and interconnected complex road networks with interchanges and multimodal elements from an operational and safety point of view. The document suggests recommendations to improve traffic conditions, efficiency, safety, and the comfort of road users. Additionally, it was written to promote and share knowledge and improve the understanding of relevant ventilation design, signaling, and operations with respect to large underground and interconnected infrastructure.

Introduction to the RAMS Concept for Road Tunnel Operations[14]

In the United States, there are 526 road tunnels that supports more than 2 million lane-feet of roadways and over 15 million of average daily traffic highway agencies strive to operate and maintain tunnels in an efficient and cost-effective manner while also complying with safety requirements. The PIARC Technical Committee D.5 Road Tunnel Operations proposed the Reliability, Availability, Maintainability, and Safety (RAMS) framework to support service, structural, and safety objectives of highway agencies in the life cycle management of tunnels while reducing their life cycle costs. The RAMS approach is applied across the life cycle phases from conceptual planning through decommissioning.

The RAMS methodology is widely used by various countries around the world. The PIARC Technical Committee D.5 identified that more than one-half of the 23 interviewee countries apply RAMS framework in some form. Of these countries, Norway and Australia have applied RAMS-based standards in the operations and maintenance of tunnels proactively, systematically, and holistically. This report illustrates with examples, how the RAMS framework is currently applied by these countries to support and optimize operations and to maintain their road tunnels. The PIARC Technical Committee D.5 also recognized the need for developing standards and recommendations to facilitate wider deployment of this emerging approach in road tunnel operations. In the interim, the PIARC Technical Committee D.5 developed seven recommendations for moving forward with this approach.

The RAMS methodology, which is new to tunnel practice in the United States, presents a "system engineering" framework to the construction, maintenance, and operations of tunnels. However, many recent and ongoing research efforts in the United States are comparable to the RAMS methodology. These research efforts advance the practice toward adopting a systematic approach for tunnels. A systematic approach would help tunnel owners

[13] https://www.piarc.org/en/order-library/32270-en-LargeUnderground%20Interconnected%20Infrastructure
[14] https://www.piarc.org/en/order-library/30270-en-Introduction%20to%20the%20RAMS%20Concept%20for%20Road%20Tunnel%20Operation

achieve the underlying principle of RAMS: to reach the desired levels and continuity of service at lower life cycle costs through coordinated preservation and safety management activities. Nevertheless, the RAMS methodology would supplement various past, current, and planned approaches in achieving the asset management goals of tunnels in a structured manner.

Road Tunnels: Vehicle Emissions and Air Demand for Ventilation[15]

Vehicular emissions are a significant contributor to air pollution in road tunnels. Adequate ventilation is necessary to maintain fresh air and dilute pollutants under traffic operations and control the spread of smoke during a fire incident. The PIARC Technical Committee D.5 Road Tunnel Operations prepared a technical report to support the tunnel ventilation system. This technical report presents an assessment methodology to calculate pollutant flow rate from vehicular emissions and required airflow rate for emission dilution to maintain fresh air for a tunnel ventilation system. As the emission standards of new vehicles are constantly changing over time, this report presents a database of emission rates to calculate pollutant flow rate of exhaust pollutants and no exhaust particle emissions by vehicle type and vehicle technology classes. The database presents emission rates that reflect the emission standards of vehicles in 2018 and enables forecasting of emission rates until 2035.

In the United States, the National Cooperative Highway Research Program has developed guidelines for state DOTs to improve road tunnel fire emergency ventilation systems (EVS). FHWA has been developing technical guidance on fully integrated fixed firefighting (FFFS) and EVS systems. FHWA has also coordinated with the tunnel community to increase awareness and gain industry acceptance of an integrated FFFS-EVS systems. This report supplements the ongoing national efforts with tunnel ventilation system designs.

Damage and Deterioration Assessment Decision-Making for Highway Bridge Safety[16]

Bridge owners strive to keep highway bridges in acceptable condition to ensure safety, functionality, and structural performance for the traveling public. Under service, the bridges may deteriorate because of frequent use or because of damage caused by random events or incidents. Damage to these key pieces of infrastructure may pose significant hardship to the safety and operations of the motoring public if damage is not quickly identified and repaired.

This report was prepared by Working Group 3 of the PIARC Technical Committee D.3 Bridges. The major objectives of this document were to provide an updated perspective on the best practice of damage assessment techniques used by bridge owners and to detail a decision process for bridge owners to use as a guide during damage assessments. The United States provided key contributions to the content and particularly the editing of the English language version.

The PIARC Technical Committee D.3 conducted a detailed analysis of damage assessment techniques used by bridge owners of various countries and how safety decisions were made. The purpose of this analysis was to provide an update on best practices in bridge inspection and management. The PIARC Technical Committee D.3 conducted a questionnaire survey and received responses from 15 countries on their practices. The Committee also received 28 case study examples that provided information on incidents that caused damage to bridges, damage assessment techniques used, specific strategies, actions taken, outcomes, and lessons learned. Using the findings from the questionnaire responses and case studies, the PIARC Technical Committee D.3 produced a decision-making process for bridge owners to use as a guide during damage assessment to make decisions on engineering, analytical, and field assessment needs. The Committee also published the information gathered from individual case studies.

[15] https://www.piarc.org/en/order-library/30189-en-Road%20Tunnels:%20Vehicle%20Emissions%20and%20Air%20Demand%20for%20Ventilation.
[16] https://www.piarc.org/en/order-library/31368-en-Damageand%20Deterioration%20Assessment%20Decision-Making%20for%20Highway%20Bridge%20Safety.

Six of the 28 case studies are based on the bridges in the United States. This report also highlighted two novel techniques used in the United States: Phased Array Ultrasonic Testing and High Energy X-ray Testing. Furthermore, the UAS, one of the techniques cited in the report, is currently used by more than 35 state DOTs. Despite this sophistication, the United States can investigate and potentially adopt advanced assessment and analytical techniques adopted by other countries for bridge inspection and management. Overall, participation in this report and PIARC, allows the United States to showcase the significant developments made on the topic to the world.

Disaster Information Management for Road Administrators[17]

Information management is an essential element of an emergency response strategy and action plan of transportation agencies. Collecting, processing, sharing, and updating reliable information in a timely fashion is necessary to ensure effective communication and engagement with internal and external stakeholders, including road users and the public, in pre-event, during, and post-event phases of disasters.

Technological advances in telecommunication and social media provide a distinct opportunity for transportation agencies to collect and convey information instantaneously for disaster management purposes. The PIARC Technical Committee E.3 Disaster Management performed a four-year study of "Disaster Information Management" and "Disaster Management with the Public.", The Committee also developed a web-based "Risk and Disaster Management Manual."

The PIARC Technical Committee E.3 presented eight case studies of advanced practices in information processing and sharing of disaster warning systems, social networking services, and ITS from six countries, including the U.S. This report also identified best practices for developing public engagement strategies to timely communicate reliable disaster information and manage road user expectations on service restoration. The PIARC Technical Committee E.3 has developed a web-based risk and disaster management manual with graphic user interface that hosts a collection of reports, methodologies, toolbox, and case studies.

The practice of emergency or disaster management in transportation agencies has evolved over the years. In the United States, transportation agencies have followed the Federal Emergency Management Agency's (FEMA's) National Incident Management System guidance to develop emergency operations plans. Agencies follow a comprehensive set of policies, guidance, and procedures outlined in their emergency operations plans to perform their disaster management functions. However, like many advanced countries, these functions have predominantly focused on providing responses during a disaster event. In recent years, agencies have worked toward an integrated emergency management approach that includes planning and preparation before an event, response during event, and recovery in post-event phases. The United States has developed a detailed guide for both leadership and practitioners at state transportation agencies on evaluating and developing effective emergency management strategies.

In addition, the United States has a matured practice in leveraging advanced technologies during emergencies. technologies include ITS, automated warning systems, mobile communications, and social media. The United States has also developed real-time monitoring and sophisticated communications capabilities for voice and data flow to have a common operating picture at emergency operations centers and traffic management centers. The U.S. Department of Homeland Security's Unified Incident Command and Decision Support architecture facilitates these capabilities. In addition to these developments, the United States has also established advanced early warning and remote sensing systems, such as satellite imagery, sensors, UAS, FloodCast for flood warning, and ShakeCast for early earthquake warning. Despite these advanced capabilities, transportation agencies have shortcomings in ensuring seamless information flow among construction, design, and maintenance systems

[17] https://www.piarc.org/en/order-library/30746-en-Disaster%20Information%20Management%20for%20Road%20Administrators.

to support the damage assessment and recovery phases. The work produced by the PIARC Technical Committee E.3 can help inform United States practices.

Intra- and Inter-Agency Integration of Winter Maintenance Management: Case Studies[18]

The principal authors were Steven Lund of the Minnesota Department of Transportation (MNDOT) and Gabriel Guevara of the FHWA. This document included ten case studies from six countries, capturing noteworthy examples of cooperation within and between agencies responsible for winter maintenance management. The report highlighted two U.S. case study examples on the inter-agency and intra-agency coordination: MNDOT and the National Capital Region.

One of the intra-agency cooperative efforts highlighted was the coordination between MNDOT maintenance and traffic operations during winter driving conditions at the regional transportation management center. One of the inter-agency examples was the inter-agency coordination conducted by the Transportation Planning Board (TPB) of the National Capital Region in the Greater Washington, D.C., Metropolitan Area. The National Capital Region Transportation includes the District of Columbia and eleven local jurisdictions in Maryland and Virginia. The TCP coordinates regularly with transportation agencies of the District of Columbia Department of Transportation, States of Maryland and Virginia, and various other federal, state, and local agencies, to provide a coordinated response and situational awareness of transportation operations. This multi-jurisdictional coordination is performed to minimize problems associated with uncoordinated and fractured agency responses to events, such as winter weather, construction work zones, transit services and traffic incidents.

The case studies highlighted that early and continual coordination and communication lead to good collaboration, real-time data collection, and improved decision-making and show that short-term savings may not produce long-term efficiencies.

Low Cost ITS[19]

Since first introduced during PIARC's 2012–2015 cycle, continual improvements in Intelligent Transportation Systems (ITS) technology have reduced the cost and increased the adoption of various technologies. While initially aimed at low- and middle-income countries, the affordability of lower cost technologies is of benefit to high-income countries as well by increasing the availability of ITS to smaller agencies within these countries.

As new technologies emerge with lower entry points, low cost ITS will allow for a simplified data collection process chain, easier information dissemination, and speedy deployment of ITS systems. The low cost ITS also improves the efficiency and safety of the transportation system at a fraction of a cost that traditional approaches need. The report focuses on identifying innovative services that can be deployed in the near term and provide future roadmaps for implementation. The research is complete with business models that identify costs and benefits for ITS, including:

- Alternative business models
- Public-private partnerships

The report addresses challenges for ITS implementation for road network operators when faced with social equity considerations. It is concerned with how to transition to an appropriate high- or low-cost solution while maintaining a high level of service. Furthermore, this guide notes that lower cost ITS devices may come with tradeoffs, however, and the savings need to be weighed against the greater functionality provided by more expensive devices. In lower-volume or more remote locations, a low-cost localized solution may still provide significant safety and operational benefits compared to a fully networked or more robust installation.

Partnerships through PIARC allow the dissemination of information beneficial to countries of all socioeconomic levels which allows them to participate

[18] https://www.piarc.org/en/order-library/30259-en-Intra-%20and%20Inter-Agency%20Integration%20of%20Winter%20Maintenance%20Management:%20Case%20Studies
[19] https://www.piarc.org/en/order-library/30406-en-Low%20Cost%20ITS

in technological advances in technology designed to help create an overall high-performing transportation system that can increase capacity and lower the negative aspects often associated with transportation. It is beneficial for FHWA, PIARC, and other participating organizations to share innovations that bring equity across all levels of transportation systems.

The Snow and Ice Data Book 2018[20]

As winter storm events are becoming more frequent and intense, the road network managers face a challenging mission of keeping the roadways open and clear from snow and ice to ensure safer and less disruptive travel. *The Snow and Ice Data Book* serves as a data book summarizing the experiences of 28 countries in their efforts in winter maintenance. For each of the 28 countries, this report presents information on climate conditions, winter climate indices, winter maintenance practices, tools and technologies and standards, stakeholder coordination, and ongoing research and improvements. By referencing similarities and innovations in winter maintenance, the report offers a valuable resource to understand innovations across countries and provide contacts to help propagate an efficient winter management and mitigation system worldwide.

The report highlights several experiences that are worth noting for winter maintenance. France has used porous asphalt that allows heat transfer fluid (water) to circulate and prevent snow from sticking or ice from forming. It also doubles as a self-sufficient energy loop for solar energy uses. A similar concept of pavement heating systems was used in Korea and in China. China has also been incorporating less polluting/corrosive composite snow melting agents, and Japan introduced the Intelligent Salting Control Optimization System, which automatically spreads the optimum amount of salt using road surface data from Contact Area Information Sensing. Sweden incorporates a "Winter Model" to calculate socioeconomic costs of winter maintenance strategies on road users, road authorities, and local communities. Canada (Quebec) and the United Kingdom are using surveillance and data logging systems to better use winter maintenance resources.

The United States has had a matured winter operations practice since the 1990s. Transportation agencies have continuously advanced their winter operation practices with advanced snowplow techniques, anti-icing techniques, adaptive route optimization, and information exchange between a network of road weather information systems and winter operations. The report affirms that the road weather management practices in the U.S. are comparable to those of advanced countries. The United States will need to monitor innovative technologies and techniques related to winter services processes. For example, some European countries, including Finland, Germany, Norway, and the United Kingdom, have embedded roadway sensors to indicate key metrics, such as pavement temperature, frost depth, friction, and wind direction. As many as 20 state transportation agencies are experimenting with sensor technologies. Learning from the experiences of the European agencies will help U.S. transportation agencies expedite their advancement to full-scale implementation.

The countries highlighted in the *Snow and Ice Data Book* are Andorra, Argentina, Austria, Canada, Quebec, China, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Italy, Japan, Latvia, Netherlands, New Zealand, Norway, Poland, South Korea, Lovenia, Spain, Sweden, Switzerland, United Kingdom, and United States of America.

Truck-Traffic on Highways for Sustainable, Safer and Higher Energy-Efficient Freight Transport[21]

The greater presence of freight transport on highways and motorways results in increased concerns about greenhouse gas (GHG) emissions, congestion, traffic safety, etc. Developed by the PIARC Technical Committee B.4 Freight Transport, this report aims to share research and findings on management and

[20] https://www.piarc.org/en/order-library/30797-en-The%20Snow%20and%20Ice%20Data%20Book%202018.
[21] https://www.piarc.org/en/order-library/31308-en-Truck-Traffic%20on%20Highways%20for%20Sustainable,%20Saferand%20Higher%20Energy%20Efficient%20Freight%20Transport.

operation of truck traffic on highways and motorways, with a goal of more efficient, environmentally friendly, safer, and energy-efficient truck transport.

To address increasing concerns related to freight transport on highways and motorways, the report highlights innovative policy measures, advanced technology use recommendations on truck management on highways, and means for energy efficiency, alternative fuels, electrification, and routing optimization. For interurban heavy freight vehicles, the report proposes the electrification of road freight through direct, overhead contact line for electricity supply with battery power for first mile/last mile trucking. Alternative fuels of compressed natural gas have good potential if enough sustainable biomethane can be made available at a reasonable cost.

The United States has embarked on the journey to the electrification of road freight. The private sector has established a coalition to develop a roadmap to advance toward an electrified freight system. The FHWA is establishing a national network of alternative fueling and charging infrastructure along National Highway System corridors. Other HIC countries, such as Australia, Japan, and various European countries, have a more mature practice. For example, Australia has developed an Intelligent Access Program that uses satellite tracking and telematics to remotely monitor the movement of freight trucks, while Japan has implemented an automated truck platooning technology. Their experiences can help inform U.S. efforts in this area.

TRANSFORMATION: Implementation-Related Practices and Tools

FHWA has long worked to collaborate with stakeholders to increase transformation across the United States and worldwide through multiple initiatives. FHWA has focused on innovative practices that align with their priorities and goals to enhance the safety and performance of the nation's transportation system through research and by accelerating the development and deployment of promising innovative technologies and practices.

Innovation can solve complex business problems and increase efficiency across organizations as new technologies change the paradigm of existing practices. As road agencies in the United States prepare to design for the future, they will rely in purpose-driven research and innovation to meet the challenge of the present and modernize a transportation system of the future that serves everyone today and, in the decades to come. By collaborating with PIARC and other international counterparts, new creative technologies are discovered, tested, and assessed to determine their desirability and feasibility for implementation. Innovations are evaluated to determine whether the technology is proven and market-ready and whether it can provide a high return on investment. Once implemented and propagated across multiple organizations, it advances the quality and sustainability of the overall transportation system. The innovations highlighted through this report are vital topics on the horizon that can positively change the transportation system globally. Disseminating information on innovations helps to enlighten on what is possible and feasible to improve the quality of life and drive an economical transportation system while reducing costs and enhancing safety.

Good Practices on Multi-Modal Freight Transport Policies and Truck Management on Highways[22]

A prosperous economy and a thriving society have a crucial link with freight transport systems. The PIARC Technical Committee B.4 Freight Transport conducted a review of truck management and energy-efficient freight movement projects, initiatives and policies undertaken by 10 member countries. This report documents member countries' effective practices through a series of 13 fact sheets. The fact sheets summarize survey results capturing:

- Multimodal national policies for freight transport and logistics documented through "national case studies, good practices analysis, and

[22] https://www.piarc.org/en/order-library/29866-en-Good%20Practices%20on%20Multi-Modal%20Freight%20Transport%20Policies%20and%20Truck%20Management%20on%20Highways.

valuable lessons of less successful policies and practices" that demonstrate feasibility, transferability, and transformation.

- Truck traffic management strategies that demonstrate sustainability, safety, and energy efficiency in freight transport.

More specifically, this report highlights several notable findings related to policies and business processes that support more effective systems management (transportation systems management and operations) and to freight planning that emphasizes stakeholder coordination and identification of investment needs.

A few noteworthy examples from the 13 two-page fact sheets (one of which is the U.S. National Highway Freight Program).[23] Further detail is easily accessible by referring to findings organized in a common set of sections: short description, background, elements, related measures, impacts and benefits, success factors, and outlook and transferability.

Speed management in work zones (Czech Republic) – The viaZONE system applies algorithms to speed detector data (radar, Bluetooth) and displays pictographs on portable or mobile variable message signs to manage speed in work zones. Results indicated that drivers adjust their speeds, improving throughput by 25 percent and lane occupancy by 15 percent, thereby reducing GHG emissions.

Truck parking information system (Austria) – A truck parking information system assists operators in locating free parking along expressways and motorways. Parking lot occupancy is continuously monitored at regional traffic management centers via high-definition cameras and software updates relevant, corridor-specific information on overhead LED displays. Parking lot camera feeds can also be accessed online and through an app. The primary expected benefit is driver safety.

Truck road user charging (Belgium) – Belgium implemented a per-kilometer charge in three regions for trucks weighing over 3.5 tons in April 2016. Trucks are equipped with an onboard unit and charged a rate based on distance, road type, and gross vehicle weight, and Euro emission class. In less than two years, the share of distance driven by trucks meeting stricter emissions requirements (Euro 6) increased from 29 percent to more than 50 percent.

The Use of Unmanned Aerial Systems for Road Infrastructure[24]

Advancements in technology have brought UAS to multiple organizations where they are being used to innovate data collection. For relatively low costs, UAS can provide a viable tool for high-quality data collection. The ***Use of Unmanned Aerial Systems for Road Infrastructure*** report highlights the savings and advances seen in this dynamic and thriving technology. The research identifies massive potentialities in the following use cases:

- Bridge inspection
- Unpaved/gravel road conditions
- Automated asphalt pavement inspection

The report offers information on further advances in UAS applications, including:

- Preconstruction land surveying
- Roadway construction monitoring
- Traffic monitoring
- Urban mapping
- Avalanche monitoring
- Crash scene analysis

The research also identified the following advantages of UAS over traditional methods:

- Low cost
- Readily available off the shelf, with customizing as required
- Quick turnaround in data download and efficiency
- Ability to access remote locations
- Enhanced safety for humans

[23] https://www.piarc.org/ressources/publications/11/29875,2018CS02-EN.pdf
[24] https://www.piarc.org/en/order-library/29470-en-The%20Use%20of%20Unmanned%20Aerial%20Systems%20for%20Road%20Infrastructure

While UAS can be advantageous and can provide many benefits, some challenges were identified including:

- Lack of standard specifications
- Data storage
- Safety in densely populated areas
- Battery life limitations

As transportation organizations further innovate their practices, the need for detailed data and improved methods is growing. UAS can play a critical role in gathering detailed and accurate information, assisting with data collection and inspection needs for broader and cross-cutting applications, such as construction inspection, stockpile measurements, hazard assessments, asset inspection and maintenance, emergency response operations, and traffic monitoring. As technology advances, further from the broad adoption of UAS, increased funding is expected, and innovation will spawn additional benefits. The demand for advanced sensors and increased capability will drive other innovations as needs are identified and funded. Many transportation organizations are now using UAS and continue to find new uses and innovations through their use. Internationally, public, and private sector UAS growth has been occurring at a rapid pace. Examples of UAS innovations can be found across the globe, but technical capabilities, priority sectors, regulatory environments, and operational frameworks vary greatly by country and region.

FHWA gained useful information through involvement in the PIARC sponsored project on ***The UAS to Remotely Collect Data for Road Infrastructure.*** PIARC outsourced the project to the private sector on a proposal submitted by FHWA. The report highlights the value in the use of UAS in obtaining vital information on roads in remote, and hard to reach areas. The report also shares modernizations to help propagate additional advances across the world.

Sustainable Multimodality in Urban Regions[25]

The rapid development and globalization of cities have led to a concentration of activities, employment opportunities, and overall populations. Consequently, the need for transportation and mobility in and around cities has increased, and public space has become scarce. Organization and optimization of existing transportation systems is now an imperative. The PIARC Technical Committee B.3 Sustainable Multimodality in Urban Regions works to give insight on sustainable multimodality in urban regions. By sharing experiences, observations, and best practices at an international level, the report prepares road authorities to develop a sustainable response to meet the needs of the inhabitants of these urban areas.

The report highlights experiences and potential solutions that work toward three themes: accommodation of metropolitan regions' mobility needs extending to surrounding suburban and rural accessibility while considering social equity and cost; development that limits transport needs while still accommodating the needs of those outside the urban core; and new mobility applications, such as networking applications, shared-use mobility, electric bicycles, etc.

The report also emphasizes the importance of land use and urban development. The formal spatial structure of cities, functional patterns of land use, and spatial interactions are basic aspects of a cities that have traffic and environmental impacts. Transit-oriented development (TOD) is crucial in city planning, and according to the America THINKS survey, the desire to live near public transportation routes has increased over the past five years for 29 percent of Americans. TOD will reduce dependency on driving, which reduces carbon footprint, and allow residents more flexibility and access to a higher quality of life.

This report demonstrates the successes of various road-based and transit-oriented solutions with case study examples from various countries. In the U.S. context, this report highlights the success stories of managed

[25] https://www.piarc.org/en/order-library/30850-en-Sustainable%20Multimodality%20in%20Urban%20Regions

lanes, bus rapid systems, and transit-oriented strategic planning in American cities; however, other promising multimodal solutions, including shared mobility, non-motorized transport, and multimodal transit centers in large cities, are yet to mature in the United States. Both state and local transportation agencies can learn from the experiences of other countries.

National Policies for Multi-Modal Freight Transport and Logistics[26]

A well-functioning logistics and freight transport system is critical to sustaining a thriving economy. Robust national policies are essential for a well-functioning logistics and freight transport system. These policies, which seek to optimize the use of all models, will contribute toward developing and implementing an overall consistent transport strategy. Such policies will lead to a more efficient logistics and freight transport system and reduce negative impacts on the population and the environment. However, national policies for freight transport are often undervalued compared to those of passenger transport.

The purpose of this report is to provide an understanding of multimodal freight policies through discussions of trends and challenges that hinder optimal utilization of multimodal freight transportation. Developed by the PIARC Technical Committee B.4 Freight Transport, the report outlines the challenges that affect freight transportation, drivers behind these policies, and analysis of survey findings. It provides recommendations on how to develop policies that ensure optimal usage of multimodal freight transportation. A national logistics/freight master plan must be developed, and freight should be integrated into national, regional, and local policies. Optimization of freight flows require involvement of several types of infrastructures. Policies should give dedicated funding to facilitate efficient movement of freight by all modes, and the multimodal freight policy should incorporate infrastructure management, financing, and regulation.

This report presents a detailed discussion of multimodal freight transportation trends based on the survey inputs from 19 different countries, including the United States. This report emphasizes the need for national policies and strategic plans to guide multimodal freight strategies. Per the Fixing America's Surface Transportation Act (FAST) on national multimodal freight policy, the USDOT has developed a National Freight Strategic Plan through extensive consultation with freight stakeholders in both public and private sectors, following which, many state transportation agencies have developed state Freight Plans and established state Freight Advisory Committees.

Connected Vehicles - Challenges and Opportunities for Road Operators[27]

The deployment of connected vehicle technologies is advancing in many developed countries. As these technologies are integrated into vehicles, they offer many opportunities and challenges for road operators, road design, and road operations. The adoption of connected vehicle innovations is expected to improve the overall transportation system by integrating additional communication among vehicles, roadside infrastructure, and traffic networks.

Opportunities identified in this report relate to the fields of road safety, traffic management, and traffic information, and cooperative intelligent transport systems (C-ITS) can help advance countries in the direction of Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V) communication. Not only do these technologies have the potential to reduce costs but also generate revenue for road operators. Many challenges are still associated with deployment of these technologies.

For countries and regions that want to become involved, the report outlines some of the best practices based on the experiences of current C-ITS deployments. Developed by the PIARC Task Force B.1 Road Design and Infrastructure for Innovative Transport Solutions, this report provides insight into the various deployments of connected vehicles worldwide and provides information on best

[26] https://www.piarc.org/en/order-library/31319-en-National%20Policies%20forMulti-Modal%20Freight%20Tra
[27] https://www.piarc.org/en/order-library/30786-en-Connected%20Vehicles%20-%20Challenges%20and%20Opportunities%20for%20Road%20Operators

practices, lessons learned, and general adoption advice for agencies looking to integrate connected vehicles into their transportation systems.

This report provides recommendations to road and traffic operators and authorities to support this C-ITS implementation route. In summary, the report gives a well-coordinated approach for clear plans, introduction of these technologies, and standardization of the technologies for vehicle manufacturers to ensure and accelerate deployment. Adequate promotion of the benefits in this implementation route and supporting policies and regulations at a national level will ease the introduction of and deployment as well. Also, investigation and support to produce cheap and easily integrated V2I dedicated short range communication retrofitted devices will expand the benefits to the existing fleet. This can be built on the knowledge gained from several C-ITS trials in Europe and around the world.

The United States has a similar trajectory of maturity with European countries in connected vehicles technology and deployment. The national vision for automated driving systems, which was developed using extensive stakeholder outreach, is articulated in the USDOT's Automated Vehicles Comprehensive Plan. The individual state DOTs, such as Utah, Arizona, Michigan, and Colorado, are taking a lead in developing their own connected automated vehicle capabilities in partnership with the private sector.

However, the United States has an opportunity to learn from the experiences of European countries. Both the United States and Europe have comparable technological capabilities but follow different standards. For example, the United States follows Basic Safety Message approach, while Europe follows Cooperative Awareness Message and Decentralized Environment Notification Message standards. Nevertheless, there are opportunities to learn from a unified approach to high-priority issues, such as safety, data, privacy, and interoperability.

In summary, the outreach activities led by FHWA and PIARC have brought together highway stakeholders, including state DOTs, industry partners, and other public agencies, to help improve understanding of the issues related to connected vehicles. These efforts provide a conducive atmosphere for engagement to better inform research, programs, and policies related to the adoption of connected vehicles.

Big Data for Road Network Operations[28]

Prepared by the PIARC Technical Committee B.1 Road Network Operations/ Intelligent Transport Systems, this report captures the global practices on the management and use of big data to improve traffic operations and enhance mobility. This report highlighted case study examples of big data from seven countries: Australia, Czech Republic, Japan, Netherlands, South Korea, the United Kingdom, and the United States.

The report presents a definition of big data in the transportation context that encapsulates three pertinent characteristics: a large volume of data, high velocity of data collection, and a variety of data of different formats usually from several sources. As many of the datasets are collected and aggregated by nongovernmental entities, including industry and social media, smaller agencies and governments have the potential to tap into large troves of data without directly supervising collection. To educate the stakeholders, the report illustrates the data process, from the generation of data from various traditional and non-traditional sources to the creation of information, and their applications for services.

This report focuses on the proven current applications of big data as well the future potential for road network operations:

- Improved traffic management, which highlighted the Czech Republic's use of big data in traffic flow prediction and decision-making for effective traffic management.

[28] https://www.piarc.org/en/order-library/31185-en-Big%20Data%20For%20Road%20Network%20Operations

- Improved road network operation services, which highlighted the uses of big data in the automation of signal performance in Utah, congestion reduction in Australia and Netherlands, and near real-time dashboards of operational performance in London.
- Automated weather detection that highlighted the applications in weather monitoring in South Korea during Winter Olympic Games
- Improving planning and operations tasks that highlighted the applications in evaluating transportation network performance with an example from Perth, Austria.

Emerging applications of big data in Mobility as a Service and Connected Vehicles ecosystem were discussed. The report discusses how big data plays an essential role in the bi-directional exchange of data between road network operators and connected vehicles through C-ITS services with citations of developments in Europe and Japan. The report also discusses how big data could help road network operators in enabling and enhancing coordination and communication among key public and private stakeholders for improved mobility.

The PIARC Technical Committee B.1 also discusses the implementation needs as well as challenges relating to standardization, ownership, and privacy to make transportation agencies ready to handle big data.

Regulation and Transformation

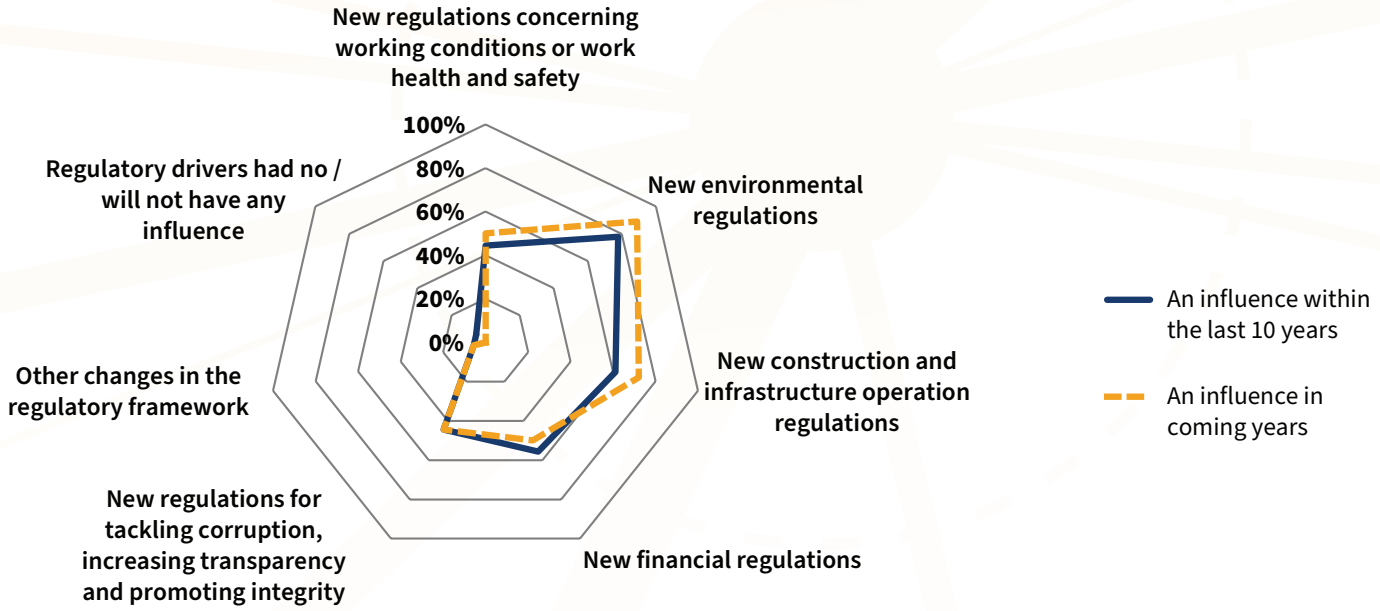
Through its work documented in the report ***Evaluating the Transformation of Transport Administrations***[29], the PIARC Technical Committee A.1 Performance of Transport Administrations states that, by their nature, transportation agencies are elements of systems of public governance and are therefore often beholden to "bureaucratic heritage." This phenomenon may inhibit rapid changes in the adoption and adaptation of innovation in the industry due to traditional and complex management procedures, administrative protocols, and regulatory compliance requirements. The Committee found that compared to other public agencies and the private sector, infrastructure providers tend to have more risk-aversion, are conservative, centralized, have hierarchical organizational processes, values, and culture. On the other hand, staff in public agencies are more likely to be motivated by serving the public interest, and this should be positively harnessed through change management exercises.

Improving an agency's capacity to transform, be more administratively efficient, and to better respond to the needs of the public through regulatory reform is often challenged by the entropic nature of regulations themselves. PIARC has few reports that show reductions in regulations. Rather, research has been focused on drivers, might introduce new regulations in the coming years. Figure 1, reproduced from the report ***Evaluating the Transformation of Transport Administrations,*** indicates what types of new regulations might be expected based on key drivers from 22 surveyed transportation agencies around the world. These predictions track closely to experience over the last 10 years, although future environmental, construction, and infrastructure operations regulations are predicted to increase notably over prior years' baseline. As Figure 1 illustrates, Anticipation of new environmental regulations follows from a focus on environmental sustainability.

One driver not explicitly addressed in the PIARC Technical Committee A.1's report is regulation on data privacy. The PIARC Technical Committee B.1 **Road Network Operations/Intelligent Transportation Systems** report on big data suggests agencies should focus on or be familiar with developments in data privacy regulations (e.g., the principle of 'privacy by design'), which will play an increasingly important role in the adoption of automated vehicles (AVs) and how they function, connected infrastructure and operational applications, and the collection and use of data generally by agencies to improve planning, investment decision-making, and customer service applications.

[29] https://www.piarc.org/en/order-library/31283-en-Evaluating%20the%20Transformation%20of%20Transport%20Administrations

FIGURE 1. **EXTERNAL DRIVERS – CHANGES IN THE REGULATORY FRAMEWORK**
SOURCE: EVALUATING THE TRANSFORMATION OF TRANSPORT ADMINISTRATIONS 2019R21EN



Organizational and Workforce Development

Internal capability improvements to an organization and its workforce are longstanding transportation agency objectives. Rapidly developing opportunities for transformation and the need to respond to shifting industry demands underscores the criticality of these pursuits.

Developed by the PIARC Task Force A.2 Coordination between national and sub-national authorities, the report titled "Principles for Cooperation and Collaboration between National and Local Road Agencies"[30] explored workforce capabilities and skills in the context of cooperation and collaboration between national and subnational or local transportation agencies. The PIARC Task Force A.2 emphasized the need for transportation agencies to create and maintain a competent workforce through qualifications and continuous education. To quote from the report, the PIARC Task Force A.2 notes: "institutions often act as custodians for creating a culture of safety and professionalism." The PIARC Task Force A.2 cited several strategies that help maintain a high degree of workforce competency:

- Require professional certifications and methods of practice.
- Promote the transferability of qualifications across boundaries (internationally).
- Maintain connections to academic institutions to ensure relevant courses of study to agency needs.
- Support diversity and inclusion (e.g., apprenticeships, more routes to accessing the profession) and strengthen team performance through contributions from diverse backgrounds.
- Provide continuous learning and professional development through courses, events, webinars, podcasts, competency schemes, etc.
- Stay abreast of new developments and future competencies.

National agencies serve an important role in engendering a sense of professionalism, when national authorities provide or support technical and administrative training that is open to all levels of governments; and when professional societies, associations and boards are relied upon to qualify engineers and certify technical skills." (PIARC Task Force A.2, 2016-2019 Cycle).

[30] https://www.piarc.org/en/order-library/34417-en-Principlesfor%20Cooperation%20and%20Collaboration

The emergence of big data will shape the future workforce development activities. The PIARC Technical Committee B.1 report on big data[31] highlighted the emerging and future applications of big data in planning, design, and operation of transportation networks. Capitalizing on this development will require investment in data science skills to complement expertise in the transportation network operations and management domain. The needs include:

- Data scientists who analyze data to solve business problems and support decision-making on business strategy adoption. Data scientists have specific skills that incorporate analytics, statistics, machine learning, computer science, and geospatial science to develop statistical models; they employ data pattern recognition and apply visualization techniques to interpret and explain findings related to variables and datasets.
- Data engineers/analysts/architects who can "find, organize, clean, sort, and move data." Data scientists leverage their work to solve business problems while "[t]he data engineer designs, builds, and manages the information infrastructure of big data." (PIARC Task Force A.2, 2016-2019 Cycle)
- IT resources to support software, hardware, and network needs, including data managers, security managers, business architects, and data change agents.

[31] https://www.piarc.org/en/order-library/31185-en-Big%20Data%20For%20Road%20Network%20Operations

OUTCOMES AND ACCOMPLISHMENTS THROUGH PARTICIPATION IN PIARC

The impact of FHWA's participation in PIARC is far-reaching and involves the expansion of knowledge, sharing of outlooks and obstacles, and making connections that strengthen the effectiveness of U.S. transportation community initiatives.

Flagship Products

Reports and accomplishments from the 2016–2019 cycle that align with FHWA's strategic priorities for the U.S. Transportation industry include:

- Road Safety Manual (2019)
- Large Underground Interconnected Infrastructure (2019)
- National Policies for Multi-Modal Freight Transport and Logistics (2019)
- Evaluation of Organizational Approaches to Risk (2019)
- Low Cost ITS (2019)
- Innovative Approaches to Asset Management (2019)
- The Use of Unmanned Aerial Systems for Road Infrastructure (2018)
- Bridge Design Toward Improved Inspection and Maintenance (2019)
- Paving Solutions and Sustainable Pavement Materials (2019)
- Earthworks Manual (2019)
- Framework on Measuring Effectiveness and Efficiency of Transport Administrations (2019)
- Ex-Post Evaluation of Road Products (2019)
- Intra- and Inter-agency Integration of Winter Maintenance Management: Case Studies (2019)
- Sustainable Multimodality in Urban Regions (2019) [Primary: Infrastructure]
- Disaster Information Management for Road Administrators (2019)
- Principles for Cooperation and Collaboration between National and Local Road Agencies (2020)

Key Outcomes

During the 2016–2019 cycle, PIARC executed a more consistent production of interim products within the Technical Committees and Task Forces, as well as from the deliberations and discussions of PIARC's corporate bodies. Key outcomes of participation include:

- **Technical Knowledge Sharing:** U.S. delegates are exposed to new ideas and innovations from cutting-edge thinkers from countries that lead in specific technical topics. U.S. Delegates support the international road transportation community through knowledge transfer when the United States has specific technical expertise.
- **Perspective and Context:** Involvement in the PIARC exposes delegates to the problems faced around the world by the road transportation community and allows them an opportunity to work collaboratively on solutions to common issues. The community benefits from the understanding and experiences of countries with similar geographic, weather, social, and financial circumstances.
- **Expanded Professional Networks:** U.S. delegates build professional relationships with professionals they would otherwise not meet. PIARC participants are often involved in day-to-day transportation operations and are an excellent source of technical information.
- **Special Projects Program:** PIARC established the Special Projects Program to support projects outside the rubric of its Strategic Plan to more

quickly complete smaller bodies of work to address critical issues. U.S. involvement in these PIARC Special Projects aims to fill in knowledge gaps and obtain information on emerging road-related policies and practices in support of FHWA's priorities. Projects that produced timely information for many countries, including the United States, were related to:

- Use of Unmanned Aerial Systems (UAS) for road infrastructure.
- The impact of overweight vehicles on road infrastructure and road safety.
- Compilation of both existing "business as usual" and state-of-the-art road-related data collection and analysis technologies.

Future Opportunities

The 2020–2023 PIARC cycle is currently underway. Topics for this cycle include safety and sustainability, mobility, and road administration, with emphasis on vulnerable road users, resilient infrastructure, risk management, connected and automated vehicle technology, and public-focused strategies.

U.S. representation in the PIARCs Technical Committees and Task Forces for the 2020–2023 cycle is comprised of 40 participants. Of those, 22 are from state Departments of Transportation nominated by AASHTO. For the first time in recent history, seven U.S. representatives hold leadership positions either as a Technical Committee Chair or an English-speaking Secretary.

With the theme of "Adapting to a Changing World" and an increased focus on resilience, PIARC members convened for the World Winter Service and Road Resilience Congress held virtually. The emphasis on resilient infrastructure, regardless of climate, naturally complements the theme of winter service for it strengthens infrastructure better equips transportation leaders with planning, and it provides effective winter service.

The pinnacle PIARC collaborative event is the World Road Congress held each cycle. This cycle's premier event will take place in Prague in 2023 where the work of PIARC committees from multiple member nations will culminate. The 27th World Road Congress will serve as a forum to share the accomplishments achieved over the current four-year work cycle. Each PIARC Technical Committee and Task Force will contribute by preparing a technical session on its topic and collaborating on other types of sessions and activities. As in the previous cycle, the United States is expected to have a robust participation, where it will share technical expertise with global partners.

WORK PRODUCTS & KNOWLEDGE TRANSFER FROM 2016-2019 CYCLE

Summary

Multiple work products were prepared to document U.S. leadership, participation, and takeaways from participation in the PIARC 20-16-2019 cycle and the 2019 World Road Congress. The work products are available in print and online formats:

- FHWA Office of International Programs
- AASHTO
- PIARC

HANDOUT:	The 29th World Road Congress Overview
REPORT:	U.S. Participation in World Road Congress Discussion Summaries by Topic: Management and Finance, Access and Mobility, Safety, Infrastructure, Special Projects (19)
TECHNICAL REPORTS:	2016-2019 Cycle Technical (46)
CONFERENCE:	The 29th World Road Congress
COMPILATION REPORT:	U.S. Participation in World Road Congress: Discussion Summaries
FACTSHEETS:	Transportation takeaways from PIARC (by FHWA goals: Overview, Safety, Infrastructure, Transformation)
PRESENTATION:	Webinar: U.S. Leadership on the International Superhighway: Benefits and Accomplishments of the World Roach Association (PIARC) 2016-2019 Cycle
VIDEOS:	Leadership on the International Stage Applying Knowledge from the International Stage
EMAIL:	Leadership and Benefits from U.S. Participation in PIARC Takeaways and Outcomes from U.S. Participation in PIARC
WEB PAGE:	FHWA Office of International Programs, PIARC 2016-2019 Cycle

U.S. Participation in World Road Congress: Discussion Summaries

The 26th World Road Congress (WRC) was sponsored by PIARC and held in Dubai October 2019, with participation by 120 countries that included a United States delegation made up of the FHWA, AASHTO, TRB, state DOTs, academia, and private sector firms. U.S. delegates participated in nearly two dozen sessions and workshops. This document is a compilation of U.S. presentations delivered at the Congress, organized by FHWA strategic themes (Management and Finance, Access and Mobility, Safety, Infrastructure, and Special Projects). Each presentation is prefaced with a synopsis that describes topic alignment with FHWA strategic goals and AASHTO Standing Committees and summarizes key conclusions/observations.

MANAGEMENT AND FINANCE

- Overview of The Federal-Aid Highway Program
- The Power of Enabling Technologies to Bring About Accessible Transportation
- Evaluation of Organization Approaches to Risk
- Organizational approach to Risk-Based Stewardship & Oversight (RBSO)

ACCESS AND MOBILITY

- Low Cost ITS
- Challenges and Opportunities for Multi-Modal Freight Transport and Logistics USDOT-FHWA Truck Parking Initiatives
- Intra-Agency and Inter-Agency integration of Winter Maintenance Management: Case Studies

SAFETY

- Overview of the Road Safety Manual – Past Evolution and Perspectives
- Road Safety Manual and the ITE Road Safety Professional (RSP) Certification
- Advancing implementation of Proven Safety Countermeasures in the U.S.

INFRASTRUCTURE

- United States of America's National Report - The Story Not
- Always Well Told: The Infrastructure Preservation
- Green Paving Solutions and Sustainable Pavement Materials-State of the Art
- Monitoring Pavement Response Using In-Pavement Sensors
- Innovations in Asphalt Technologies and Characterization for Airport Pavement Use
- Damage and Deterioration Assessment Decision-Making for Highway Bridge Safety

SPECIAL PROJECTS

- The Use of Unmanned Aerial Systems (UAS) to Remotely Collect Data for Road Infrastructure
- I–5 Bridge Collapse Over the Skagit River
- Case Study "Leo Frigo Bridge"

2016–2019 Cycle Technical Reports

The 17 U.S. strategic PIARC Technical Committees and four Technical Task Forces published 46 technical reports, organized for alignment with the 2016–2019 Strategic Plan. The reports are the output of the work of over 1,000 experts during a four-year work cycle. These reports provide a state-of-the-art international best practice on roads and road transport in a context of integrated and sustainable development.

STRATEGIC THEME A MANAGEMENT AND FINANCE

Technical Committee A.1 - Performance of Transport Administrations

- Framework on Measuring Effectiveness and Efficiency of Transport Administrations
- Evaluating the Transformation of Transport Administrations
- Good Governance and Anti-Corruption and Response Measures Including the Development of a Culture of Transparency and Accountability

Technical Committee A.2 - Road Transport System Economics and Social Development

- Journey Time and Travel Reliability
- Ex-Post Evaluation of Road Projects

Technical Committee A.3 - Risk Management

- Project Risk Catalogue
- Evaluation of Organizational Approaches to Risk

Task Force A.1 - Innovative Financing

Task Force A.2 - Coordination between National and Sub-National Authorities

- Principles for Cooperation and Collaboration between National and Local Road Agencies

STRATEGIC THEME B ACCESS AND MOBILITY

Technical Committee B.1 - Road Network Operations/Intelligent Transportation Systems

- Big Data for Road Network Operations
- Low Cost ITS

Technical Committee B.2 - Winter Service

- The Snow and Ice Data Book 2018
- International Development of Application Methods of De-icing Chemicals - State of the Art and Best Practice
- Intra- and Inter-Agency Integration of Winter Maintenance Management: Case Studies
- Technical Committee B.3 - Sustainable Multimodality in Urban Areas
- Sustainable Multimodality in Urban Regions

Technical Committee B.3 - Sustainable Multimodality in Urban Areas

- Sustainable Multimodality in Urban Regions

Technical Committee B.4 - Freight

- National Policies for Multi-Modal Freight Transport and Logistics
- Truck-Traffic on Highways for Sustainable, Safer and Higher Energy Efficient Freight Transport
- Good Practices on Multi-Modal Freight Transport Policies and Truck Management on Highways

Task Force B.1 - Road Design and Infrastructure for Innovative Transport Solutions

- Connected Vehicles - Challenges and Opportunities for Road Operators

Task Force B.2 - Automated Vehicles – Challenges and Opportunities for Road Operators and Authorities

- Automated Vehicles - Challenges and Opportunities for Road Operators and Road Authorities

STRATEGIC THEME C SAFETY

Technical Committee C.1 - National Road Safety Policies and Programs

- Implementation of National Safe System Policies: A Challenge

Technical Committee C.2 - Design and Operations of Safer Road Infrastructure

- Road Safety - Catalogue of Case Studies
- Review of Global Road Safety Audit Guidelines – With Specific Consideration for Low- and Middle-Income Countries
- Road Safety Evaluations Based on Human Factors Method
- Setting Credible Speed Limits - Case Studies Report

Task Force C.1 - Infrastructure Security

- Security of Road Infrastructure

STRATEGIC THEME D INFRASTRUCTURE

Technical Committee D.1 - Asset Management

- General Concept and Requirements for Asset Management Training Courses
- Innovative Approaches to Asset Management

Technical Committee D.2 - Pavements

- Reducing the Life Cycle Carbon Footprint of Pavements
- Green Paving Solutions and Sustainable Pavement Materials
- State of the Art in Monitoring Road Condition and Road / Vehicle Interaction

Technical Committee D.3 - Bridges

- Bridge Design Toward Improved Inspection and Maintenance
- Technical and Economic Considerations of Bridge Rehabilitation Methods
- Damage and Deterioration Assessment Decision-Making for Highway Bridge Safety
- Inspections and Damage Assessment Techniques - Case Studies

Technical Committee D.4 - Rural Roads and Earthworks

- Earthworks Manual - Genesis and Preamble
- Preserve Earthworks and Rural Roads from the Impact of Climate Changes
- Review of Practices Using Marginal and Secondary Materials in Rural and Industrial Areas

Technical Committee D.5 - Road Tunnels Operations

- Large Underground Interconnected Infrastructure
- General Principles to Improve Accessibility for Persons with Reduced Mobility in Road Tunnels
- Introduction to the RAMS Concept for Road Tunnel Operation
- Prevention and Mitigation of Tunnel-Related Collisions
- Road Tunnels: Vehicle Emissions and Air Demand for Ventilation

Regional Group PIARC/Association of African Road Managers and Partners

- Methodological Document for the Establishment of a National Catalogue and Pavement Design Guide
- Contribution to the improvement of the general guidelines for the development, construction / reconstruction, rehabilitation, and maintenance of the Trans-African Highway network - (Annex II) (only in French)
- Review of the Practical Guide to Pavement Design for Tropical Countries (in French only)

STRATEGIC THEME E CLIMATE CHANGE, ENVIRONMENT, AND DISASTERS

Technical Committee E.1 - Adaptation Strategies/Resiliency

- Refinement of PIARC's International Climate Change Adaptation Framework for Road Infrastructure
- Adaptation Methodologies and Strategies to Increase the Resilience of Roads to Climate Change – Case Study Approach

Technical Committee E.2 - Environment Considerations in Road Projects and Operations

- Traffic Noise – Best Practice Guide
- Best Practice Guide to Air Quality in Relation to Road Operations

Technical Committee E.3 - Disaster Management

- Disaster Information Management for Road Administrators

SPECIAL PROJECTS

- Positive Energy Roads
- Electric road systems: a solution for the future?
- The Use of Unmanned Aerial Systems for Road Infrastructure
- PIARC Databook of Roads and Road Transport (2014-2018)
- Investigating Unpredicted Infrastructure Failure

Transportation takeaways from PIARC participation were summarized in fact sheets aligned with FHWA goals.

- PIARC Overview and Highlights
- Safety
- Infrastructure
- Transformation

FACT SHEETS

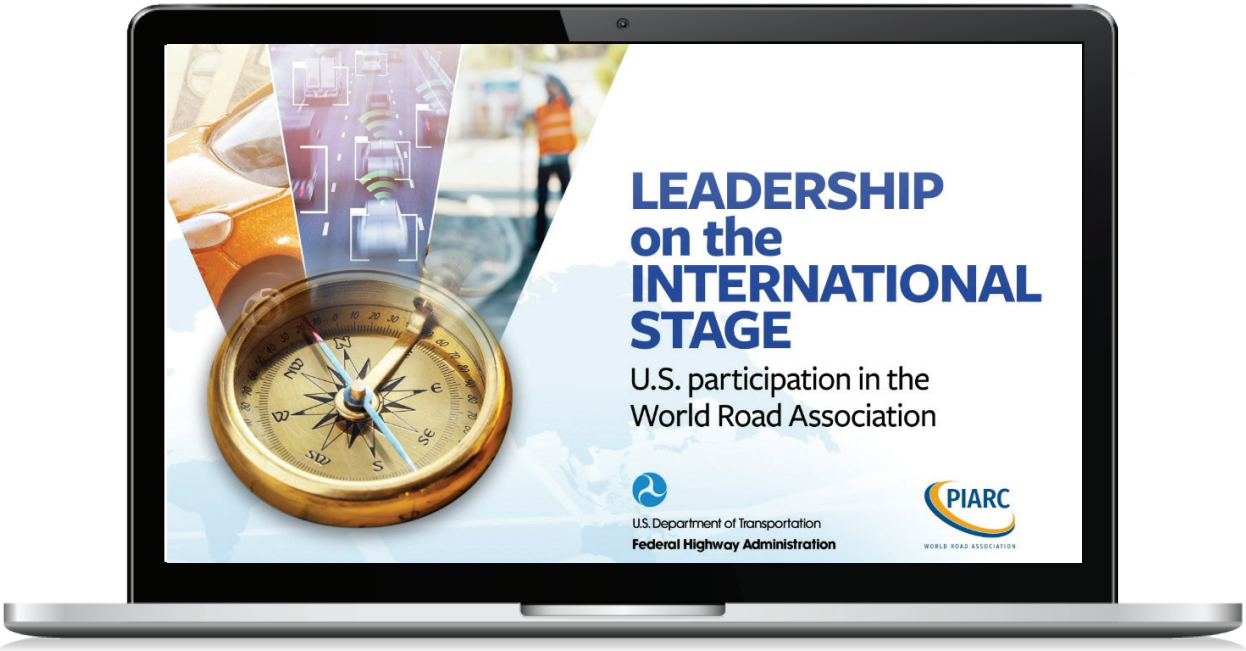
WEBINAR PRESENTATION

The U.S. transportation community benefits from PIARC through sharing of technical knowledge, gaining global perspective and context to U.S. transportation issues, and expanding members' professional networks. During a webinar hosted on December 10, 2020, participants from the U.S. transportation community discussed their firsthand experiences and achievements during the 2016–2019 cycle.

INFORMATIONAL VIDEOS

Two informational videos were prepared for the U.S. transportation community to highlight PIARC leadership and takeaways from participation in the 2016–2019 cycle.

- Leadership on the International Stage
- Applying Knowledge from the International Stage



BROADCAST EMAIL ANNOUNCEMENTS

Two broadcast emails were distributed to the U.S. transportation community to broaden distribution and access to 2016–2019 cycle work products.

- Leadership and Benefits from U.S. Participation in PIARC
- Takeaways and Outcomes from U.S. Participation in PIARC

U.S. Department of Transportation
Federal Highway Administration

PIARC

Leadership and Benefits from U.S. Participation in PIARC

PIARC, formerly known as the World Road Association, is focused on improving transportation systems through the sharing of ideas and information among road transportation experts from around the world. PIARC's committees focus on addressing timely transportation issues and delivering much-needed products—like research, industry best practices and emerging technologies—with far-reaching benefits that align with Federal Highway Administration (FHWA) strategic goals for safety, infrastructure, and innovation.

The 2016-2019 PIARC cycle included:

17 technical committees
4 technical task forces
46 published technical reports
5,000+ attendees (including U.S. delegates) at the 2019 World Road Congress held in Abu Dhabi

Coming Together

Participants from AASHTO and FHWA come together with the road administrations of 120+ governments, academia, and the private sector from 140 countries during a four-year operating cycle driven by a strategic plan focused on topical themes.

Learn more about the 2016 – 2019 cycle and its benefits by watching **"Leadership on the International Stage"** and downloading the **PIARC Overview & Highlights factsheet**.

Knowledge Sharing

The U.S. transportation community benefits from PIARC through sharing of technical knowledge, gaining global perspective and context to U.S. transportation issues, and expanding members' professional networks. During a **webinar** hosted on December 10, 2020, participants from the U.S. transportation community discussed their personal experiences and achievements during the 2016-2019 cycle.

2019 World Road Congress

The U.S. delegation at the 2019 World Road Congress comprised representatives from FHWA, AASHTO, TRB, State Departments of Transportation, academia, and private sector firms. Representatives participated in nearly two dozen sessions and presented 19 papers focused on progressing timely, multimodal transportation goals in the areas of safety, infrastructure, and innovation, which have been compiled into the **U.S. Participation in the World Road Congress: U.S. Papers Compilation Report**.

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U.S. Department of Transportation
Federal Highway Administration

PIARC

Takeaways and Outcomes from U.S. Participation in PIARC

The U.S. transportation community has a long-standing commitment to participation in PIARC (formerly World Road Association), which not only provides global knowledge, practices, and solutions for improving U.S. transportation systems and for advancing new transportation initiatives, but also offers a global platform for communicating U.S. developments to the world.

In the 2016-2019 cycle, U.S. delegates participated in product development that will advance the global transportation industry and are available at no cost on the PIARC website.

Participation summary sheets:

- **Safety**
- **Infrastructure**
- **Innovation**

Participants from AASHTO and FHWA, and road administrations of 120+ governments, academia, and the private sector— from 140 countries— come together during PIARC's four-year operating cycle shaped by PIARC's strategic plan focused on topical themes.

Video:

Applying Knowledge from the International Stage

PIARC participation by the U.S. transportation community expands knowledge and understanding, facilitates sharing of future outlooks and obstacles, and develops connections that strengthen the effectiveness of U.S. transportation initiatives.

"We're proud of the PIARC successes in the 2016-2019 cycle and look forward to the forthcoming achievements of the 2020–2023 cycle, focused on the timely themes of safety and sustainability, mobility, and road administration, with an emphasis on vulnerable road users, resilient infrastructure, risk management, connected and automated vehicle technology, and customer-focused strategies."

— Agnes Vélez

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WEB INFORMATION PAGE AND GRAPHIC LINKS

Work products from the 2016–2019 cycle are posted online:

- FHWA Website: Office of International Programs
- PIARC Website
- AASHTO Website