



PIARC 26th World Road Congress

Connecting Cultures & Enabling Economies

Abu Dhabi 2019

General Report



This report was prepared by GHD under contract with Abu Dhabi Department of Transport on behalf of the United Arab Emirates.

Executive Summary

General

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In line with their strategic vision of being the world's leader in the exchange of knowledge on roads and road transport policy, as well as all practices within the context of integrated, sustainable transport, the governing body's four key mission pursuits include the following:

- Being a leading International Forum for analysis and discussion of the full spectrum of transport issues related to roads and related transport;
- Identification, development and dissemination of best practices, and providing better access to international information;
- Full consideration within the breadth of activities the needs of both developing countries and countries currently in transition; and
- The design, production and promotion of efficient tools for decision making on matters related to roads and related transport.

A key component of the World Road Congress strategy, in pursuing its range of strategic objectives, is its characteristic of rotating around the global network, and honing in on strategic cities, countries and regions, at relevant periods of time, in order to enhance the applicability, resonance and experience of the Congress.

The XXVI World Road Congress was the first of its kind to take place within the Middle East region. This momentous occasion marks a profound achievement for the region in establishing itself as a significant and respected participant on the international stage in respect to the PIARC organisation and its core mission and values.

Congress

Since the first congress held in Paris in 1909, the PIARC quadrennial World Road Congress has served as the governing body's central vehicle to drive its strategic mission, as well as its integral calibration mechanism at the end of each four year research cycle to refocus, adjust and grow each technical committee, as desired and required.

The Abu Dhabi Department of Transport (DoT) won the bid to host the prestigious 26th Congress and identified the topic "Connecting Cultures, Enabling Economies" to enable multilateral talks regarding new ideas towards better understanding of road infrastructure and surface transport works.

The devised programme aimed to achieve a balanced mix of forums, level of detail, content and context, while keeping true to proven past successes, but also pushing the envelope with new features and initiatives.

Opening Session

The Congress invited globally-recognised dignitaries and prominent scholars such as leaders of research institutes and global businesses and ministers of member countries. The intent of these invitations is to allow the sharing of successful stories and experiences that can provide participants with new visions and inspiration for the future.

The welcome address by H.E. Dr. Abdullah Belhaif Al Nuami, Minister of Infrastructure Development and Chairman of the Federal Transport Authority – Land & Maritime, gave insightful remarks on the origins of the congress, the significance of UAE and Abu Dhabi as the host and the wish that the distinguished work at this congress will add to every individual's knowledge.

The President of the World Road Association, Claude Van Rooten, welcomed everyone on behalf of the World Road Association PIARC, and graciously thanked the hosts and the organising committee. The PIARC Chair of Committee on Communications, Marie-Claude Petit, joined the stage in order to present a range of PIARC prizes designed to promote professional excellence, research, innovation and application that demonstrates great interest and success in all areas of roads and road transport.

The PIARC Secretariat General, Patrick Mallejacq, officially launched the Congress Programme. He highlighted that the rich programme had been structured from a total of 387 papers selected. He reinforced the point of exchanging ideas, best practice and projects is more important than ever, due to the growing rate of change in what the future holds.

Formal Sessions

'Future Transport Networks', 'Artificial Intelligence for Road Infrastructure' and 'Land Use Planning' were the topics of the three ministerial sessions held on the first day. Attended by 40 ministers and a 3000-strong audience, these sessions, chaired by official representatives of the UAE, focused on the importance of data in proper planning, the contribution that new technologies can make to enhance road transport services and achieve safety strategy goals.

The keynote speech sessions offered a range of one-hour discussion sessions on various topics which affect not only roads and transport, but which also draw the important links to society, economy, as well as politics. The intent of the keynote speeches was to set the underlying tone of the congress and summarise the bigger overarching trends impacting on the industry.

Strategic Direction Sessions

The programmes Strategic Direction Sessions are designed to define future strategies on the point of political and strategic views in order to identify each technical committee's activity paths in detail for the following four year period, which will be under the framework of five strategic themes determined every four years.

The five strategic direction themes for this Congress included management & finance, access & mobility, safety, infrastructure, climate change, environment & disasters. The sessions were prepared based on the content detailed in national reports handed over by member countries of the Association from around the world.

Foresight Sessions

Looking forward, planning and creating a better, safer, more efficient future is fundamental to our industry's DNA. The programmes Foresight Sessions are specifically designed to consolidate the relationship between PIARC and other international and regional organisations active in the field of road and transport future planning. The Foresight Sessions are also an opportunity to present important and newly emerging topics that have not yet been addressed by any of PIARC's Technical Committees, Task Forces or Strategic Direction Sessions. Foresight Sessions have a strategic aim at being forward-looking, broadening, and giving concrete examples of solutions and directions that are relevant for the audience.

Special Project Sessions

Each four-year cycle, PIARC pursue a range of what is categorised as Special Projects. Special Projects are a facility to pursue important topics outside of the strict framework of PIARC technical bodies. They enable the organisation to outsource the development of high-level, short documents that respond to critical issues identified by members, as and when required.

The Congress' Special Sessions are an opportunity to present important and newly emerging topics that have not yet been addressed by PIARC's Technical Committees, Task Forces or Strategic Direction Sessions. They aim at being forward-looking, broadening, and giving concrete examples of solutions and directions that are relevant for the audience.

The five strategic projects for this Congress included the following:

- Unpredicted Infrastructure Failures
- Unmanned Aerial Systems (Drones)
- Positive Energy Roads
- Contribution of Road Transport to Sustainability and Economic Development
- Electric Road Systems

Special Projects Sessions are designed to consolidate the relationship between PIARC and other international and regional organisations who are active in the field of road and transport.

Technical & Task Force Sessions

The Congress' Technical & Task Force Sessions are designed to share specific activities, global status analysis, as well as major achievements of each PIARC Technical Committee or Task Force, during the four-year cycle. Moreover, these sessions will discuss topics linked to the state-of-the-art in the specific fields and will propose the future directions for the next four-year cycle (2020 to 2023) based on the strategies discussed within the Strategic Direction Sessions.

In preparation of the Sessions, the World Road Association officially called for individual contributions across the following five general and twenty-one specific themes. These Sessions were all prepared and chaired by the relevant chairs of the associated PIARC Committees and Task Forces.

Closing Session

The closing ceremony was launched with a powerful live performance from the Abu Dhabi Police Brass Band, which was then proceeded by a video montage of key highlights and snapshots taken throughout the five days of congress proceedings, with overlying vocals by Claude Van Rooten, President of PIARC. The head of the Congress organising committee, Jonathan James, then delivered an all-encompassing wrap up of the Congress, honing in on the salient points which mark its legacy.

The PIARC Secretariat General, Patrick Mallejacq, then presented the key technical conclusions from the Congress, and in essence, what was achieved. He premised his remarks on the basis that Roads need to find their place in a larger context of diversity and change, which ultimately requires a holistic approach and a global dialogue between authorities, regulators, citizens, service providers, industry and stakeholders.

He declared it was the mission of PIARC to structure and share knowledge in ways that more readable, accessible and importantly, implementable, and showcased that the mission had been taken on by over 1200 experts, structured into committees and task forces, and presented here to the broader community on the work completed over the last four years, via reports, presentations and engagement.

The PIARC President, Claude Van Rooten, then held the stage to outline his closing remarks of the Congress. He thanked everyone associated with the industry, both in attendance at the Congress, as well as those not in attendance but who quietly, diligently and effectively push the industry towards its objectives.

The final closing address was then delivered by H.E. Dr. Abdullah Belhaif Al Nuami, Minister of Infrastructure Development and Chairman of the Federal Transport Authority – Land & Maritime.

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1. Foreword

The General Report of the XXVI World Road Congress has been prepared under the supervision of the Strategic Planning Commission of the World Road Association (PIARC), the representative body responsible for PIARC remaining a leading international organisation for creating and transferring knowledge in the road transport sector.

This General Report has been written by David Rolland (GHD Pty Ltd) and Andrew Saunders (GHD Pty Ltd), with contributions from Jonathan James (Abu Dhabi Department of Transport) in his role as head of the Congress organising committee, as well as from PIARC's General Secretariat, i.e. Patrick Malléjacq and Robin Sébille, and importantly the Congress Session Chairs and Technical Committee Chairs.

The preparation of this report was made possible due to an enthusiastic team of young transport engineers, the next generation of road and transport practitioners, who attended, made notes and prepared summary reports on each of the congress sessions, in order to provide an additional account of the key issues. We thank them for their contributions.

2. Preface

This General Report was prepared by an independent team of reporters tasked with capturing, reviewing, summarizing and documenting the fundamental core of content covered across the full breadth and depth of the Congress's technical programme as documented in the summaries prepared by the Congress Session Chairs.

This report sets out a structured summary of each technical focus area in a simple, thorough and consistent format. It includes not only the prefacing background to the issues, but a summary of the current focus issues and development areas, along with key outcomes, resolutions, findings and results; and importantly, the associated impacts on both key decision makers and PIARC (and other international organisations).

The objective of this report is to produce a central document that acts as a historical archive for future reference requirements, as well as a guiding blue print to map the course for the next four years of road and transport technical development and advancement.

3. World Road Association (PIARC)

The World Road Association (PIARC) was established in 1909 as the world's leading governing body on roads and associated road transport related focal points. It is a non-profit association, established to promote international cooperation on issues pertaining to roads and road transportation. It consists of a wide range of members from every corner of the globe (over 120 countries), with its core members being road agencies.

In line with their strategic vision of being the world's leader in the exchange of knowledge on roads and road transport policy, as well as all practices within the context of integrated, sustainable transport, the governing body's four key mission pursuits include the following:

- Being a leading International Forum for analysis and discussion of the full spectrum of transport issues related to roads and related transport;
- Identification, development and dissemination of best practices, and providing better access to international information;
- Full consideration within the breadth of activities the needs of both developing countries and countries currently in transition; and
- The design, production and promotion of efficient tools for decision making on matters related to roads and related transport.

Throughout its existence it has dedicated itself to a set of basic fundamental values, including:

- The provision of universal quality service to its members;
- Being open, objective and impartial;
- Promotion of sustainable and sound economic solutions;
- Recognition of road transport in an integrated transport and land use context;
- Being customer driven; and
- Respecting the differing international road transport needs.

The successful achievements within each of the above four strategic missions, and the overall successful progression, through the short and long term challenges, relies profoundly on the ability to participate in routine, widely represented, focused, high intensity, face to face contact events in order to achieve:

- Greater penetration and impact;
- Peak efficiency and effectiveness; and
- A truly global perspective and participation.

4. Local Context

4.1 General

A key component of the World Road Congress strategy, in pursuing its range of strategic objectives, is its characteristic of rotating around the global network, and honing in on strategic cities, countries and regions, at relevant periods of time, in order to enhance the applicability, resonance and experience of the Congress.

4.2 Middle East

The XXVI World Road Congress was the first of its kind to take place within the Middle East region. This momentous occasion marks a profound achievement for the region in establishing itself as a significant and respected participant on the international stage in respect to the PIARC organisation and its core mission and values.

The Middle East region is currently symbolic on the world's road stage due to its insatiable appetite to be a technology leader and innovation hub, its commitment to high levels of quality and its significant value of strategic financial investment. The regional spotlight created due to the Congress's presence shone brightly with six number of technical papers submitted from across the Middle Eastern region.

Furthermore, the geographical milestone for the Congress was enthusiastically embraced by the region with representation from five regional road authorities, who took up the opportunity to participate, interact and learn about the current trends and challenges for roads and road transportation from all over the world.

The impact of this landmark Congress will be sure to resonate across the region, inspiring new developments, strategies, intellectual thought and ideas to tackle the range of regional challenges, both ongoing and emerging.

4.3 UAE

The historical transition of the United Arab Emirates from being a collection of humble fishing village settlements trading in fish and pearls, to the integral international force that it is today, via an aggressive growth pursuit, is well documented as a unique and remarkable feat. Central to this developmental growth has been a pioneering commitment to infrastructure excellence, where roads and road related transport initiatives such as surface transport, tunnels and bridges have been a core pillar.

Testament to this focus and achievement, the UAE was identified by the World Economic Forums' Global Competitiveness Report as having the best roads in the world since 2015, a title it held through to 2018. The recognition of this prestigious honour exemplified not just the past commitment but the significant degree of ongoing work from the nation to build a legacy of road excellence that can be used as an example around the world.

Of particular note is the UAE's current emergence as one of the world's pioneering forces in the fields of electrification, digitalisation and automation. It is within this realm of thought, analysis and application which positions the UAE as a timely and highly applicable location as the world navigates through what can only be described as a revolutionary crossroad.

4.4 Abu Dhabi (Department of Transport)

Abu Dhabi, the capital of the United Arab Emirates, is a world-class capital, rich in culture, history, attractions, and importantly, road and road transport infrastructure. The centre piece of this dedication to road excellence is the Abu Dhabi Department of Transport (DoT).

Abu Dhabi's Department of Transport was established in 2006 by His Highness Sheikh Khalifa bin Zayed Al Nahyan, President of the U.A.E., as the Ruler of Abu Dhabi, in order to carry out the legislative, regulatory, supervisory and control functions related to the surface, maritime transport and the civil aviation sectors in the Emirate of Abu Dhabi, as well as all commercial activities related to these sectors.

As part of its efforts to establish an integrated and sustainable transport system in line with the objectives of the Abu Dhabi 2030 Economic Vision, the DoT is responsible for:

- Formulating the policy of the transport sector in Abu Dhabi and the development strategies and plans for this sector;
- Preparing and ensuring compliance with legislation and regulations relevant to the transport sector, management, maintenance and investment of assets in the transport sector; and
- Issuing regulations and decisions aimed at enhancing the flow of traffic and maintaining the safety, security and health of the society.

In addition to planning and executing the Congress, the Abu Dhabi Department of Transport was an active contributor to the technical programme with three technical papers submitted, along with a significant number of its work force participating as Congress delegates.

The Congress provided a unique opportunity for the league of international road and transportation professionals to convene, whilst experiencing Abu Dhabi's hospitality and distinctive offerings. Choosing Abu Dhabi to host this global event could not have been more appropriate as few other places can rival its achievements when it comes to the Congress's theme: Connecting Cultures, Enabling Economies.

5. Congress Vision

5.1 General

Since the first congress held in Paris in 1909, the PIARC quadrennial World Road Congress has served as the governing body's central vehicle to drive its strategic mission, as well as its integral calibration mechanism at the end of each four year research cycle to refocus, adjust and grow each technical committee, as desired and required.

It provides a supreme and unique environment where the full spectrum of Ministers, governments, the broad ranging private sector, road and transport administrators and organisations, academics, product and solutions' providers, experts and practitioners; can all cross connect across the globally important fields of road planning, design, construction, operation and maintenance.

More specifically, the congress offers a unique and original stage to:

- Present the latest ground breaking research;
- Share knowledge, ideas and innovations, trends and developments;
- Teaching and learn techniques, strategies and best practices;
- Present and dissect pivotal experiences;
- Debate new approaches and perspectives from around the world;
- Challenge conventions and promote growth; and
- Display the newest technologies, products and services.

5.2 Themes

The Abu Dhabi Department of Transport (DoT) won the bid to host the prestigious 26th Congress and identified the topic "Connecting Cultures, Enabling Economies" to enable multilateral talks regarding new ideas towards better understanding of road infrastructure and surface transport works.

The underlying basis of this selected topic includes the following:

Connecting Cultures

- The Congress brings people and different cultures together from around the world;
- Roads connect people and places; and
- Roads can increase the quality of life.

Economy

- Roads are a catalyst to economic development;
- Roads allow people and goods to move; and
- Roads connect businesses with their customers.

5.3 Programme

The devised programme aimed to achieve a balanced mix of forums, level of detail, content and context, while keeping true to proven past successes, but also pushing the envelope with new features and initiatives. In summary the programme included:

- Formal sessions with broad appeal across the industry
 - 3 No. ministers sessions
 - 7 No. key note sessions
- Formal sessions honing in on specific expert specialisations
 - 5 No. strategic direction sessions
 - 13 No. foresight sessions
 - 5 No. special project sessions
 - 21 No. technical & task force sessions
- Informal learning sessions
 - Exhibition stands/presentations
 - Poster presentations
 - Central stage presentations
 - Side events
- Field based learning sessions
 - 6 No. technical visits
- Social sessions
 - Coffee breaks
 - Lunches
 - Gala dinner

6. Formal Sessions

6.1 General

The Congress invited globally-recognised dignitaries and prominent scholars such as leaders of research institutes and global businesses and ministers of member countries. The intent of these invitations is to allow the sharing of successful stories and experiences that can provide participants with new visions and inspiration for the future.

6.2 Opening Ceremony

The ceremony launched with a video montage of each congress held since Paris in 1908, all the way through to Abu Dhabi in 2019. This was then preceded by the arrival and welcoming of the esteemed dignitaries to the plenary auditorium and everyone was up and standing to the UAE's national anthem.

The welcome address by H.E. Dr. Abdullah Belhaif Al Nuami, Minister of Infrastructure Development and Chairman of the Federal Transport Authority – Land & Maritime, gave insightful remarks on the origins of the congress, the significance of UAE and Abu Dhabi as the host and the wish that the distinguished work at this congress will add to every individual's knowledge.

Then, with a flat palm press on the podium, His Highness Sheik Hamed bin Zayed Al Nahyan officially opened the Congress by initiating the official opening gesture which included a live sand sculpture storytelling, a video outlining the transformation of the UAE from its humble desert beginnings to its developed cityscape and a live dancing performance with representation from the wide range of the Congress' delegates.

The President of the World Road Association, Claude Van Rooten, then welcomed everyone on behalf of the World Road Association PIARC, and graciously thanked the hosts and the organising committee. He posed the fundamental question of "*Why, after 110 years do we still need to talk about Roads?*" to which he responded that Roads remain fundamentally important to our society as the backbone of Transport and support many different transportation services.

He expanded on the values, aims and objectives of the congress, and set the tone for a productive and interesting programme ahead. He stressed that PIARC's regular face to face meetings are the best way to exchange ideas, in a collaborative manner. And encouraged all delegates to discuss, to talk, to exchange and to meet with each other.

He also highlighted the breadth of focus of the congress, highlighting that the scope goes well beyond just roads, and branches out to economics, sustainability, human factors, and many other issues. Along with the need to be dynamic in reacting to the road community's changing interests, needs and priorities, in order to ensure all products, reports, manuals, seminars and congresses, address issues of concern in a timely manner and provide value to all.

Importantly, he noted that the Council of the World Road Association-PIARC, had approved an ambitious strategic plan for 2020 to 2023. But noted that the Congress formed an important juncture in wrapping up the work in the previous cycle, and transition into the new cycle.

The PIARC Chair of Commission on Communications, Marie-Claude Petit, then joined the stage in order present a range of PIARC prizes designed to promote professional excellence, research, innovation and application that demonstrates great interest and success in all areas of roads and road transport. The recipients included:

- Category: Safety of road user and worker
 - Recipient: Effort in Mexico to implement a road safety audit system
- Category: Best Innovation
 - Recipient: Alternative secondary raw materials for road construction based on pulp and paper rejects
- Category: Developing Countries
 - Recipient: Economic growth through effective rural road asset management
- Category: Road Design & Construction
 - Recipient: Opportunity and challenges with automation in road construction and condition monitoring in England
- Category: Road Maintenance & Operation
 - Recipient: Substitution of asphalt with waste expanded polystyrene

The PIARC Secretary General, Patrick Mallejacq, then officially launched the Congress Programme. He highlighted that the rich programme had been structured from a total of 387 papers selected. He reinforced the point of exchanging ideas, best practice and projects is more important than ever, due to the growing rate of change in what the future holds.

Claude Van Rooten, then re-joined the stage to officially launch the new PIARC logo, via a video launch. The logo is shown below.



6.3 The Ministers Sessions

6.3.1 General

This session, one of the highlights of the congress, allowed participants to get together and follow presentations of member countries' Ministers on the challenges and solutions of each nation.

'Future Transport Networks', 'Artificial Intelligence for Road Infrastructure' and 'Land Use Planning' were the topics of the three ministerial sessions held on the first day. Attended by 40 ministers and a 3000-strong audience, these sessions, chaired by official representatives of the UAE, focused on the importance of data in proper planning, the contribution that new technologies can make to enhance road transport services and achieve safety strategy goals.

6.3.2 Future Transport Networks

Connected technology and innovative transport services are providing opportunities to change the way solutions are provided, connecting cities and neighbourhoods. A well-designed and efficient transport system contributes to economic growth and helps in refining the quality of life of the people, and is thereby one of the most important sectors for development.

In essence, this theme was selected to explore the following fundamental questions affecting our industry:

- How does a government set the policy agenda for the future with all these different modes available?
- How do governments decide what modal and service-type share goals to achieve?
- How do they prioritize investment into different modes and service types?
- How do they engage with innovative transport service providers?
- When the policy goal is agreed, how do they get society to change their current transport choice behaviours?

This session was represented by the following ministers:

Australia

Michael McCormack, Deputy Prime Minister and Minister for Infrastructure, Transport & Regional Development

Drawing reference to the challenges associated with working with such vast distances for future planning, the Deputy Prime Minister highlighted the inherent opportunities within planning on such a scale. Linking strong trading partnerships (such as the UAE) and the need to rely on rapid times to bring food and fibre to the ports, he outlined a new infrastructure spending programme, including a substantial road proportion.

Cambodia

Sun Chanthol, Ministry of Public Works and Transport

In addressing how future transport policies were crafted, the Minister drew reference to the fact that the vast spectrum of infrastructure across the county was destroyed during 30 years of internal conflict. Subsequently, over the last 20 years, rebuilding and rehabilitating has centred around joining the capital city with the

range of provincial capitals to increase connectivity, increasing the quality of roads to create longer lasting infrastructure and strong engagement with the relevant stakeholders.

Equatorial Guinea

Rufino Ovono Ondo Engonga, Minister for Transport, Postal Services & Telecommunications

The Minister replied on the short- and long-term road transportation plans for the nation.

Korea

Kee-Choo Choi, Vice Minister of Land, Infrastructure and Transport

When pushed on the range of transport challenges and what the government is doing to overcome them, the Minister was categorical in his response citing congestion, road safety and environmental pollution. Specifically, he outlined the need to introduce express services (for highway and rail) and the focus risk area of drowsy drivers.

Montenegro

Osman Nurković, Minister of Transport and Maritime Affairs

The Minister drew reference to the way their government plans its transport agenda

Myanmar

Kyaw Linn, Deputy Minister of Construction

The minister elaborated on their nations imitative to implement multiple strategic road corridors to capitalize on being the land bridge between two major trading partner neighbors (China & India) in order to maximize economic growth and development.

Senegal

Oumar Youm, Minister of Infrastructure, Land Transport and Opening-Up

The Minister commented on the notable road infrastructure investments initiated by the nation in order to strategically improve mobility.

Singapore

Baey Yam Keng, Senior Parliamentary Secretary of the Ministry of Transport

Drawing reference to Singapore's commitment to being a leader in new technology, the Senior Parliamentary Secretary was asked to elaborate on how they manage the challenges associated with implementation. His response included the need to maintain an open mind and a forward looking mind set, a strong focus that trials are completed in a safe and controlled manner, and that a high degree of consultation is completed, including citizens and industries.

Spain

José Luis Ábalos Meco, Minister of Development

The Minister explained the notable road network challenges faced by the nation in respect to quality and quantity of current infrastructure.

Sweden

Mattias Landgren, State Secretary for Infrastructure

After being branded with the safest roads in the world, the State Secretary was asked how the nation was planning to stay ahead of the pack. Although gracious in accepting the accolade, he ensured that the focus remained on improvement, and that nothing less than zero incidents would be tolerated. Along with embedding road safety within the political ideology, he stressed further work needed to be done to reduce the environmental impacts associated with transport systems and to transition in a way that provides new business opportunities, jobs and prosperity.

United Kingdom

Nusrat Ghani, Minister for Accessibility and Skills

When pressed on whether the nation's citizens were embracing the new transport models, the Minister admitted that creating the vision was one thing but securing participation was a step harder, which sometimes required a governmental nudge in the right direction. There was an acknowledgement that some of the new models did require a substantial shift in behaviours, however that transition wasn't always straightforward and that often the barriers were psychological. She stressed governments must focus on a people centred approach, inclusivity and flexibility.

6.3.3 Artificial Intelligence for Road Infrastructure

Contribution of new technologies such as artificial intelligence (AI) has the power to enhance road transport services and achieve safety strategy goals. For example, AI can predict the potential risks of using information obtained from various interior and exterior sensors, on board vehicle computer's and cloud network services. AI can also contribute to the optimization of transport services, through the identification of demand patterns and the allocation of resources, among others.

In essence, this theme was selected to explore the following fundamental questions affecting our industry:

- How are governments addressing these new technologies and what must they consider?
- How do authorities determine whether they should adopt such a new technology?
- What infrastructure changes are required and how does a government change the infrastructure to safely accommodate these new technologies in a way that is economically feasible and forward-looking?
- How does a nation begin to regulate these new technologies?

This session was represented by the following ministers:

Angola

Manuel Tavares de Almeida, Minister of Construction and Public Works

In addressing what the infrastructure business opportunities were in Angola within the burgeoning area of AI, the Minister drew reference to the fact that were now experiencing a new governance cycle based on a new generation of consistent public policies aimed at macro-economic stabilisation, economic expansion and diversification. He noted that they were at the beginning of this cycle and still had a long way to go, however this allowed the early introduction of AI at a grass roots level.

Japan

Masafumi Mori, Former Vice Minister of Land, Infrastructure, Transport, Tourism

Drawing reference to Japan's commitment to being a leader in new technology, the Minister was asked to elaborate on where AI has been beneficial for the nation. His response included traffic congestion forecasting on major freeways, noting the level of success had initiated an expansion of this technique into other road classifications, as well as within the realm of road maintenance to combat ageing road infrastructure. He noted that the Japanese Government was partnering with industry on a range of AI research projects.

Lithuania

Jaroslav Narkevicius, Minister of Transport and Communications

After having its six-month long winter period highlighted, the Minister was asked how AI can improve road maintenance through what is historically a high road accident period. He responded that AI had already established itself as a key change maker in increasing passenger safety, reducing congestion and improving maintenance effectiveness, in ways specific to the winter constraints. Specifically, it was highlighted that 10 times less in the amount of salt had been achieved in some regions.

Malaysia

YB Baru Bian, Minister of Works

When asked what the main benefits and impacts would be after the implementation of AI on road infrastructure, the Minister outlined the ability to increase the capacity of roads without increasing the number of lanes, increased fluidity (automatic tollgates) and easier policing of road risks (overweight vehicles). He noted that Malaysia was working with its neighbours (Singapore and Japan) in order to prepare a new ITS blueprint aimed at increasing efficiency across all aspects of the road network.

Nicaragua

Oscar Salvador Mojica, Minister of Transportation & Infrastructure

The Minister addressed the question of what AI factors should be considered in the design of roads in Nicaragua.

Serbia

Sasa Stojanovic, Assistant Minister for Transport, Road and Roads Safety

Drawing reference to how nations should decide to adopt AI and how to regulate it, the Minister highlighted the fact that Serbia was behind in this game, and as part of its candidacy to join the EU, was now beginning to push forward with such advances. He noted that going digital (5G Networks) offered enormous potential for productivity, but that "Intelligence" required "Infrastructure", and that new forms of investment financing were required in order to fund the ventures.

South Africa

Dikeledi Magadzi, Deputy Minister of Transport

In addressing the question of how regulators can keep pace with AI, the Deputy Minister drew reference to the fact that South Africa was very much still in the

development phase of this new initiative. Subsequently, she noted that it was very important for other countries to share their learnings and be open about the challenges in forums such as the WRC, to allow developing countries to be ready. Specifically, she made reference to the challenge of ownership and management of data.

Ukraine

Natalie Forsyuk, Deputy Minister of Infrastructure

When pressed on whether security was a major threat in determining the benefits of AI, the Deputy Minister was emphatic in her agreement. She noted that “data” was now the new oil the 21st Century and that data security was paramount in order to prevent the weaponisation of hacked IT Systems, which unfortunately the Ukraine had already been a victim of within many of the government sectors. She highlighted that the Ukraine was a leader in open data, and that significant efforts were being undertaken to create management tools for transport mobility, economic growth and safety of its citizens.

6.3.4 Land Use Planning

Proper planning requires understanding the challenges and possible solutions, with a good grasp of the actual data at the core of transport: daily work travel patterns, traffic and public transport movements, road work requirements and major events that create congestion and affect mobility.

In essence, this theme was selected to explore the following fundamental questions affecting our industry:

- What are the components of good infrastructure planning, such as environmental impact analyses and optimal use of land?
- How can governments deliver reductions in congestion through smart mobility?
- Should we look to limit the need to travel long distances?
- What are the key considerations for transportation resilience and sustainability for the future?
- How can governments foresee what are the communities of the future and their transport needs?

This session was represented by the following ministers:

Andorra

Jordi Torres Falcó, Minister of Territorial Planning

The Minister drew reference to the key priorities are for linking transport infrastructure with land use planning.

Barbados

Peter Phillips, Minister of Transport, Works & Maintenance

When asked how governments can deliver reductions in congestion via smart mobility, the Minister outlined that their nation had approached mobility from a perspective of raw social and economic stimulus response. Specifically, they had undertaken a thorough national investigation, with significant consultation with all stakeholders, which allowed a plan for mobility development to be drafted. The

plan focuses on sustainable development, protecting core assets, advancing accessibility and greening the economy.

Burundi

Jean Bosco Ntunzwenimana, Minister of Transport, Public Works, Equipment & Land Use Planning

The Minister addressed the question of how the nation overcome the issue of urban mobility.

Czech Republic

Tomáš Čoček, First Deputy Minister of Transport

Drawing reference to the key considerations for transportations resilience and sustainability for the future, the Minister highlighted the fact that the Czech Republic was currently actively addressing a number of strategic goals across the transport sector. Specifically, they were targeting equal opportunity, zero emissions, constant growth demand, supporting public transport initiatives, pushing eco-friendly systems and the achievement of socially fair transport networks and systems. He noted that conflicts must be approached as opportunities.

Ethiopia

Hiwot Mosisa Deresa, State Minister of Transport

Drawing reference to the fact that Ethiopia's population is growing so fast, the State Minister discussed the issues with maintaining land use planning in line with the degree of economic growth. Any delay was noted as having time and cost impacts, therefore the focus was to provide a constant development focus on land use planning in order to combat the serious social, economic, political and environmental issues. However importantly, this focus on the long-term direction did have to be balanced with also addressing the short-term current issues.

Mali

Ibrahima Abdoul Ly, Minister of Transport & Urban Mobility

The Minister outlined, when pressed, how governments can deliver effective land use planning bearing in mid the economic and environmental impacts.

Paraguay

Ignacio Gómez, Vice Minister of Public Works

The nation's feature bi-oceanic corridor project was put under the spotlight by the Minister who explained the rationale behind the route.

Scotland

Michael Matheson, Cabinet Secretary for Transport, Infrastructure, Connectivity

In addressing how governments can ensure that land use planning will actually lead to a better support of infrastructure planning and sustainable outcomes, the Cabinet Secretary detailed his nation's focus areas for the policy approach. Firstly, the existing regulatory framework for making decisions should be reviewed in order to ensure the delivery of growth, empowerment and suitable for emerging challenges. Secondly, ensure the focus is on enablement, and not just regulation. And lastly, bring in new policies which set the vision, hierarchy of investment targets and which achieves sustainability.

6.3.5 Conclusion

The key points and emerging themes from this important session are summarised below:

- Developing a people centred approach to mobility, under Urban Mobility strategies
- New business opportunities with shift to zero emissions transport
- Artificial Intelligence will be the nerve system of future cities, with the capacity to handle a huge wealth of data
- Data security is critical in safeguarding future transport systems
- Land use planning needs to meet new challenges (e.g. climate change and empower communities to achieve inclusive economic growth).

6.4 Key Note Speeches

6.4.1 General

The keynote speech sessions offered a range of one-hour discussion sessions on various topics which affect not only roads and transport, but which also draw the important links to society, economy, as well as politics. The intent of the keynote speeches was to set the underlying tone of the congress and summarise the bigger overarching trends impacting on the industry.

6.4.2 Key Note Speaker No.1

His Excellency Mattar Al Tayer

Director General, Chairman of the Board of Executive Directors of the Roads and Transport Authority - Dubai

H.E. Mattar Al Tayer, delivered an inspiring speech describing Dubai's transition into one of the world's leading global transportation role models, with pioneering advances in public transport systems and integral linkages, safety, security and a range of technological pursuits, of which have resulted in one of the smartest and happiest cities in the world. He noted that few other cities encapsulated the theme of the congress of Connecting Cultures Enabling Economies with more resonance.

He extrapolated on what he thought the key pillars of this success were built on, including the following:

- Vision –The need for actively assessing and forecasting the future needs, “thinking out of the box”, allowing trial and error as well as priding oneself to be an industry leader was reinforced.
- Leadership – In order to realise the vision, the transition through the project lifecycle must be managed with toughness and directness, often requiring a very agile and personal approach for a CEO to achieve the greatest results.
- Team work – He stressed the need for the team to be unified, empowered and persistent and to remain focused, collectively challenging constraints as they inevitably surface.

Each of the three above factors were demonstrated with proud examples of Dubai's development, both past and present, which was brought to life with two

feature video pieces. The examples included the state-of-the-art Dubai Metro, the strategic ITS 2020 initiative and the Project Management Office (PMO) focused on training, knowledge transfer and policy.

6.4.3 Key Note Speaker No. 2

Dr. Etienne Krug

Director of the World Health Organisation's Department for Social Determinants of Health

Dr. Etienne Krug delivered a powerful presentation on the importance of human life, the associated impact of road transportation and the ongoing challenge of harmony between the two.

His presentation etched through the historical context of the pivotal transportation crossroads that have been navigated and the associated price that it has had on our personal safety.

He outlined a series of quite stark statistics, with the most resonant being that at present, over 1.3 million people die on the roads of the world every year, the biggest killer of our young people between 5 and 29. The notion of these statistics occurring in the context that this is an area which can be prevented, set the gravity of the situation and the need for a sustained push forward with improvement.

The philosophical question posed was *Why? Why are we accepting a transportation system that kills so many people? Why? Not just in deaths and injuries, but in the impact on health due pollution and reduced physical activity, as well as traffic jams that waste our time. Why? Is it because the number is spread out over such a wide spectrum, fatalism, no government ownership or big private sector interests?*

However, his statements were tempered with the latest data statistics that suggested that progress was finally being experienced, in that the historically increasing trend had finally reached a position of plateauing. This latest trend was coming to fruition due to a combination of targeted policies, efforts and focus, along with a greater geographical awareness across the globe.

So in signing off, he offered a degree of hope that our navigation through this next crossroad of digitalisation, that we have the conscience, awareness and intent to ensure that the latest encouraging trends continue.

6.4.4 Key Note Speaker No. 3

Nazir Alli

Founder & Chief Executive Officer of the South African National Roads Agency (SANRAL)

Nazir Alli spoke about the importance of enhancing infrastructure for social cohesion and inter-dependent trade across the African continent. With a sum of 54 No. different countries across the African continent, of which many are land locked, the cross continental road transport infrastructure linkages are a vital life line for supplying food, energy and medicine, along with providing a route out for traded goods.

The continent realised early that without infrastructure they are not going to get where they want to be, as Infrastructure is the enabler. However, he brought reference to the 1979 Lagos Plan of Action, the first attempt to have a pan-African

plan for development of the continent, which ultimately failed due to regional instability and global instability, as well as the 2001 partnership for Africa's development, NAPAC, which was constrained.

With the African population currently growing at 1.1%, and with projections of up to 2.25% by 2030, the need for expansion, efficiency, safety and governance of these critical assets is paramount.

He stressed the importance for the need of government, the private sector and, most notably, the general public, all coming together in order to work through locally appropriate solutions. As much as we can learn from each other, one solution does not fit all. In particular, he called out for the inclusion of the younger generation in the decision-making process, as they are currently calling out for economic prospects, social justice and the protection of the environment. To capitalise on the demographic dividend.

In addition, he outlined the importance of sound governance, that the institutions are capable, that there is a reduction in inequality, a greater focus on land use planning, a maximisation of the natural resources across the continent, strong leadership, and most importantly, innovative funding solutions. Specifically, he called for the private sector to do more to remove the perceived trust deficit with the public sector.

6.4.5 Key Note Speaker No. 4

Guangzhe Chen

Global Director & Transport Global Practice Regional Director for the South Asia Infrastructure Department World Bank

Guangzhe Chen spoke on the rapid growth of the middle-class population and the resultant spike in demand for mobility solutions. Key to this shift is the associated financial challenges, including rising levels of debt and a resultant investment gap.

He launched his presentation by prefacing the seven sustainability goals, where transport is essential to each and every one. However, with the exponential growth being experienced, it is clear that no single entity, being public, private or multi-lateral, will be able to fulfil the financing needs of the sector.

It was stressed that roads remain the dominant route in moving goods and people around the world. He highlighted the rise in e-commerce in hubs such as Asia, and the massive need to move freight around, and quickly, is starting to place the existing networks under a degree of strain. A trend that will only increase as the level of income increases.

In addition, the growing awareness in carbon footprints, and the need to act in order to reverse the damaging course was now an issue manifesting throughout every aspect of the industry, was noted as a significant challenge.

The current forms of finance, including public finance (from government budgets), private finance (PPP's, concessions) and official development assistance, all have limitations, including most notably fiscal restraints and frozen capital. The challenge has now been set for new and innovative modes of achieving sustainable financing, and improvement in the quality of infrastructure spending.

In respect to innovative modes, he noted ring fencing of revenue, road user charges and commercial financing options (not just loans). However, noted the importance of risk awareness and sustainability.

In respect to spending, he noted that it was not a simple issue, and that would take greater focus in the areas of critical assessment, transparency, procurement, project planning and execution, across national, regional and municipal levels. It will be hard work, with no easy solutions, but that it would likely be rewarded by greater levels of foreign investment.

6.4.6 Key Note Speaker No. 5

Jean-Luc Di Paola-Galloni

Group Corporate Vice-President of Sustainable Development & External Affairs at Valeo

Jean-Luc Di Paola-Galloni, presented on the vision for roads from the perspective of the automobile industry (including suppliers) and the powerful tech world. Highlighting the growing mobility challenges and the revolutionary pathway of electrification, digitalisation and automation, he underpinned the importance of new, collaborative and integrated research programmes to steer the course of profound opportunities and tangible risks.

6.4.7 Key Note Speaker No. 6

Luis Castilla

Chief Executive Officer of Infrastructure, Acciona

Luis Castilla, presented on the responsibility of the private sector to tackle the future challenges with a strong conscience, highlighting the untapped potential of Sustainability. He highlighted Acciona's own taxonomy of prioritizing economic activities with performance criteria for the contribution to six key environmental objectives, allowing a calculated effect to be quantified. He highlighted that this prism is being noticed by clients and called on more public authorities to adopt this focus.

6.4.8 Key Note Speaker No. 7

André Broto

Strategy Director at Vinci Autoroutes

André Broto spoke about the new realm of challenges being faced by companies operating in the construction and concessionaire sectors. How to mobilize in order to meet global challenges, as well as how best to balance economic, social and environmental performance. The importance of an integrated model that incorporates the asset lifecycle with the rapidly developing digital environment will be key to meeting future challenges was reinforced, and the need for companies to respond with new ways to engage stakeholders.

7. Strategic Direction Sessions

7.1 Introduction

The programmes Strategic Direction Sessions are designed to define future strategies on the point of political and strategic views in order to identify each technical committee's activity paths in detail for the following four year period, which will be under the framework of five strategic themes determined every four years.

The five strategic direction themes for this Congress included the following:

- **Management & Finance**
 - Funding & Financing
- **Access & Mobility**
 - Innovative Transport Solutions to Optimize Access & Mobility
- **Safety**
 - Safety of the Road System
- **Infrastructure**
 - The Story Not Always Well Told: Infrastructure Preservation
- **Climate Change, Environment & Disasters**
 - The Progress of Climate Change Adaptation & Mitigation Actions in the Transport Sector after the COP 21 Paris Agreement

The sessions were prepared based on the content detailed in national reports handed over by member countries of the Association from around the world.

7.2 Scope

7.2.1 Theme B - Access & Mobility – Innovative Transport Solutions to Optimize Access & Mobility

Background Context

The four core technological innovations at the heart of transport access and mobility, Connected, Autonomous, Shared & Services, and Electric (in other words, CASE) are all bringing significant transformation to road transportation. These evolutions have the capacity to efficiently solve a range of current issues being experienced within road transport (i.e., traffic accidents, traffic congestions, environmental burdens, etc.). However, on the other hand, the associated impacts of such transformations are uncertain and involve challenges and disruptions to the status quo.

The obligations of road administrators are to fundamentally develop new and existing infrastructure, manage roads, and design the systems to maximize the use of technological innovations. At the same time, it is necessary to analyse the impacts of these transformations on road traffic and the socioeconomic environments.

Topics

The session comprised of two integral parts, the first component of which dealt with Future Road Transport, a showcase of the new and exciting range of mobility technologies entering the market. The second component dealt with Road Traffic Optimization, which focused more on the impact that the introduction of the new technologies can, and is, having on road traffic.

Conclusions

The technical findings from the range of presentations included:

- In the absence of adequate attention to safety, an emphasis on maximizing the efficiency of road transport systems has led to significant loss of lives, health and wealth.
- "Vulnerable" road users such as two-wheelers and pedestrians are at greatest risk in developing countries while overloaded converted pick-up trucks and minibuses are often the only affordable means of motorized transport.
- The combination of unsafe vehicles, poor road conditions, and unsafe driving habits translates into injuries and deaths.
- Widespread AV adoption can reduce environmental degradation through reduced emissions and energy consumption while providing beneficial economic and social outcomes through improved efficiency, traffic flow, road safety, and accessibility to transport.
- As developing countries become increasingly motorized, cars, scooters, and other vehicles compete with pedestrians, bicyclists, and animals for road space that is often ill-equipped to handle such diverse means of transport.
- In addition to the congestion resulting from different modes of transport, lack of separation of users, lack of helmets and safety restraints, unsafe vehicles, dangerous driving habits, lack of legal enforcement, corruption, inadequate administration, and poor capacity contribute to the problem.
- Countries all over the world are constantly pursuing efforts to utilize the available road capacities to their maximum, creating a strong need (and potential incentive) to apply smart mechanisms through Integrated Circuit (IC) technologies.
- Road management by use of Big Data has now become relatively common amongst road operators in a select range of countries.
- Road traffic management with advanced technologies can be very effective at events where peak loadings are experienced.
- "Big Data" and the associated analysis is the prerequisite for the next generation of traffic management and road network operations.
- Policy measures to utilize technological innovations to deliver sustainable mobility will be the key to future road administration.

The key conclusions for decision makers within the industry are summarised as:

- It is important to look simultaneously at accessibility, mobility and safety.
- Road pricing according to traffic situation and driving distance charge for heavy good vehicles are also one of the measures to be considered.

- Mobility as a Service (MaaS) along with CASE (refer above) may advance the optimization of transport modes which wide ranging benefits to society.
- Promoting the use of other transport modes other than road transport through integrated multimodal cooperation presents a potentially viable solution to be examined in more detail.
- Road administrators are encouraged to think from the perspective of mobility services providers in order to appropriately react to the advancement of technologies.
- In order to optimize access and mobility solutions and make the most of the advanced technologies, coordination between different government agencies, such as road authorities, public transportation authorities, urban administrations, and police, etc., is also important. This is best coordinated directly by the industry decision makers.
- Prioritizing the needs of vulnerable road users includes recognizing the importance of the built environment when making political and planning decisions.
- Some of the solutions lie in appropriate modifications to the physical road environment and setting up a supportive policy framework.
- The potential integration of customer satisfaction as a KPI to measure the success of the project and people's willingness to pay a premium to drive on certain routes

The overarching conclusions for PIARC and other international organisations included:

- Collaboration between road administrators, road operators, automotive industries and IT industries is essential in order to prepare for and realise the future development set to occur in order to make our advanced transport technology commonplace on the road. PIARC is best placed to facilitate and drive this collaboration.
- It is of great importance to share the relevant and useful information elements among ALL nations and actively collaborate between each other. PIARC needs to play the leading role as the facilitator of information exchange in order to achieve inter-operability between nations.

7.2.2 Theme C – Safety – Safety of the Road System

Background Context

At present, over 1.3 million people die on the roads of the world every year, and is the biggest killer of our young people between 5 and 29. Most (91%) of the world's fatalities on the roads occur in low-income and middle-income countries. In most low-income and middle-income countries, the majority of road users are vulnerable road users – pedestrians, cyclists, and those using motorized two or three-wheelers.

However, many of the proven interventions being implemented globally – such as use of seat-belts and child restraints, vehicle standards, and crash tests – are relevant to car occupants. It is also important to consider that many of the interventions currently under examination are costly and potentially irrelevant in low-income settings.

In the context that this is an area which can be prevented, the need for a sustained push forward with improvement is required.

Topics

A number of central topics were discussed during the session including safer designs for better road safety, road maintenance for safety, vulnerable road users, road safety audits and speed and traffic management. Significant emphasis was placed on designing roads with human limitations and applying the Safe System Approach.

Conclusions

The technical findings from the range of presentations included:

- It is clear that much of the current research on road traffic injuries focuses on interventions in high-income settings. There is an urgent need to broaden the agenda and identify effective interventions that target the most common and vulnerable victims of road traffic crashes.
- Comprehensive and clear legislation, enforced with appropriate penalties and accompanied by public awareness campaigns, has been shown to be a critical factor in reducing road traffic injuries and deaths associated with speed and the non-use of occupant protection measures (helmets, seat-belts, and child restraints).
- Legislation on these risk factors is not comprehensive in many countries, and enforcement is often lacking.
- Similarly, many countries lack the institutional mechanisms and resources that would allow them to implement planned activities in a coordinated fashion – including adopting and enforcing laws – which may result in a “piecemeal” approach to road safety efforts that is seen in many countries.

The key conclusions for decision makers within the industry are summarised as:

- More research is needed on interventions that address vulnerable road users, while land use planning and road design should also take the needs of these road users into consideration.
- It is important to promote the application of recommendable practices and approaches such as:
 - Vision Zero and safe systems;
 - The establishment of credible speed limits;
 - The calming of traffic;
 - The audit, evaluation and inspection of road infrastructure;
 - Infrastructure modernization in face of the transition to future vehicle technologies;
 - Actions for the greater protection of school children and vulnerable road users;
 - The generation of new concepts and findings related to human factors and its incorporation into the design of the road systems;
 - Safer road tunnel operations;
 - Road safety data management and research; and

- Training activities for safe design, construction, maintenance and exploitation of roads.

The overarching conclusions for PIARC and other international organisations included:

- To promote the latest knowledge on current issues and facilitate technical discussions and debate among industry stakeholders.

7.2.3 Theme D –Infrastructure - The Story not Always Well Told: Infrastructure Preservation

Background Context

With significant peaks in road expansion through the 60's, 70's and 80's, we are now experiencing a peak in the volume of deteriorating assets and an associated depreciating level of service. In order to combat this trend, the industry is pursuing a range of strategic programme, policy and research responses, all targeting the preservation of assets, in all facets of the asset life cycle (planning, design, construction, operation and maintenance).

Topics

The session comprised two integral parts; the first component dealt with the “management” of infrastructure, a show case of the essential operation components such as policies, processes, equipment, data, human resources, and external contacts, for overall effectiveness. The second component dealt with the important aspect of “public communication”, which focused more on the methods to share programme, ideas, or initiatives to the general public for information, warning or action.

Conclusions

The technical findings from the range of presentations included:

- The proactive preservation of ageing infrastructure has significant potential to produce significant financial savings for asset owners and maintainers, and therefore should be getting a lot more attention across the industry than what it currently receives.
- Similarly, the ageing of the people in charge of infrastructure is an issue that has a sustainability legacy impact, and therefore should also be getting more attention.
- National roads consistently remain the priority, however effective rural road asset management has the potential to facilitate substantial economic growth.
- The dissemination of information and the associated education still remains a significant constraint across the industry.

The key conclusions for decision makers within the industry are summarised as:

- Improving all aspects of communication between the different facets of focus within asset owning and maintaining organisations is critical, and needs a lot more attention.
- Social recognition, in the form of providing employees with the tools to create meaningful outcomes, is needed in order to attract young people

into the fields of infrastructure management in order to preserve the future of critical road infrastructure maintenance.

- It is encouraged for road owners and maintainers to reference the PIARC road asset management manual where applicable.

The overarching conclusions for PIARC and other international organisations included:

- Funding of and execution of studies to highlight the significant financial advantages that can be associated with proactive preservation programmes, techniques and initiatives needs to be pushed within the industry in order to provide the breakthroughs required.
- Formulation and distribution of critical self-assessment toolkits in order to enable road agencies to critically assess their performance and guide decision making.
- Continuation of the dissemination of asset management knowledge and the education of asset managers.

7.2.4 Theme E - Climate Change, Environment & Disasters - The Progress of Climate Change Adaptation & Mitigation Actions in the Transport Sector after the COP 21 Paris Agreement

Background Context

The COP 21 Paris climate agreement led to a new climate agreement, applicable to all countries, aiming to keep global warming below 2° C, in accordance with the recommendations of the Intergovernmental Panel on Climate Change (IPCC).

The 197 “Negotiating Parties” committed to drawing up long-term low greenhouse gas emission development strategies. It is an agreement with an “Action Agenda” aimed at implementing accelerators to ensure more ambitious progress, above and beyond binding commitments.

Certain legally binding rules apply to the relevant Parties, such as the obligation for developed countries to provide developing countries with financial support to enable them to implement the agreement.

Topics

The session comprised two integral parts; the first component dealt with the effects of climate change, a show case of real-life manifestations and the associated consequences. The second component dealt with the important aspect of action implementation, which focused on the methods to share programmes, ideas, or initiatives to the general public for information, warning or action.

Conclusions

The technical findings from the range of presentations included:

- Climate change is impacting on the rates of heat expansion, flooding, rock falls and landslides.
- Event frequencies are shifting dramatically, requiring the old models to be reassessed and challenged.
- Climate change is requiring us to apply a shifting criterion to materials selection.

- The key constraints to development within this area of study and application remain budgetary (governments are experiencing fiscal restraint), computational (large scale data processing), systems and geographical (large and often remote areas required to be studied).

The key conclusions for decision makers within the industry are summarised as:

- Decision makers should apply more effort to the collection of greater volumes and higher quality data in order to be able to appropriately understand the trends and patterns.
- New models (e.g. frequency distribution curves, risk analysis and event trees) are required to be developed for site specific regions.
- A greater focus must be placed on broad sustainable solutions to problems.
- Consideration of progressive forms of fees and taxes for users (e.g. older cars pay a greater level of contribution to provide an offset mechanism).
- Consideration of smart technology applications to assist with the identification of new climate change hazards (e.g. bridge vibrations).

The overarching conclusions for PIARC and other international organisations included:

- Lobbying of car manufacturers in order to influence the design of the products which use the road networks.
- Assessment of international codes and best practice guides to address the new and changing risk profiles.
- Encouragement of the industry to be proactive and not reactive to the threats.

8. Foresight Sessions

8.1 Introduction

Looking forward, planning and creating a better, safer, more efficient future is fundamental to our industry's DNA. The programmes Foresight Sessions are specifically designed to consolidate the relationship between PIARC and other international and regional organisations active in the field of road and transport future planning. The Foresight Sessions are also an opportunity to present important and newly emerging topics that have not yet been addressed by any of PIARC's Technical Committees, Task Forces or Strategic Direction Sessions. Foresight Sessions have a strategic aim at being forward-looking, broadening, and giving concrete examples of solutions and directions that are relevant for the audience.

8.2 Scope

8.2.1 FS1 - Socioeconomic Impacts of Automated & Connected Vehicles

Background Context

In respect to regulation, it is important to understand that this is a fundamental transition period for our transportation system, and that there are a number of key questions that need to be addressed and progressed. For example, what are the potential impacts of Connected and Automated Vehicles (CAVs) on the overall level safety and public health? What is the potential for adoption/acceptance by the public of CAVs? What are their implications for establishing new regulations? Who is responsible for regulating the driving task? What are the federal vs. state and local roles? What are the insurance and liability issues? And within all of these issues, it important to address the fact that there will be different scenarios and circumstances for mixed fleets of both person and computer operated vehicles.

In respect to equity, which is broadly defined across the industry as "removing barriers to access for all people", CAVs have a number of open, yet unanswered questions. For example, what are the roles and responsibilities of different actors for CAVs? How do we ensure designing equitable access to digital platforms like CAVs is inclusive, so that all members of the community regardless of abilities can benefit? How do we ensure that there is a transition for the potential impacts to the areas that this transition looks to disrupt (i.e. labour markets)? It is not clear that governments yet know what their role is in these respects.

In respect to Land Use and Streets, the greater goals of CAVs (e.g. reduced vehicle ownership, less parking and road space needed etc.) will require a better way to manage the public rights-of-way than currently administered, which poses a range of new questions. For example, what are the right mix of tools to ensure we can still maintain and update our infrastructure? How do we overcome the political challenges to reallocating street space to ensure this transition? What is the best way to work together to ensure that the streets are prioritized for multimodal and more efficient use, so we can ensure win-wins with these systems?

Topics

This session focused on the promotion of the common understanding, efficiencies and cooperation within the international transportation community on the benefits

risks and opportunities associated with the transition from today's typical transportation service offering, and onwards towards shared, connected and automated vehicles and their range of socioeconomic impacts: regulation, equity, land use and streets.

The key question confronted within this topic was how to bring better regulatory governance into the digital era of transportation, while correcting for the existing socio-economic inequities in our system, working closer with public, private and community sector partners and the land use and street infrastructure changes needed to ensure the transition minimizes the potential challenges and optimizes those opportunities that may come out of this, as the technologies develop.

Conclusions

The technical findings from the range of presentations included:

- Regardless of the rate of progression, we will need to have to be dealing with a mixed fleet of vehicle types for a very long period of time.
- Many of the leading firms right now are already well-established big-time players, however, there appears to be a lot of alliances forming in order to ensure survival.
- The research shows that people will only likely accept new technologies when the new technologies provide a proven better (and cheaper) solution to one of their problems and it can be relied upon.
- There is still a big question within the industry around technology readiness.

The key conclusions for decision makers within the industry are summarised as:

- There is potential for significant adverse impacts if we do not get this transition right, therefore decision makers are urged to move slowly but surely.
- Collectively we need to figure out how best to transition from the current infrastructure funding strategy of gasoline/petrol taxation to a new and sustainable strategy that takes into account the full set of impacts of the new technologies.
- We need to solve the equity question now, and then bring in autonomous technology. Waiting for autonomous technology to fix the equity problems is not going to be a solution. Governments need to lead in this area and define a clear position.
- Organisations need to start transitioning their policies now. It has to be evidence and performance based as we move from restrictive to more permissive regulations.
- There must be a continuous dialog and we need to keep asking the questions until we get it right.

The overarching conclusions for PIARC and other international organisations included:

- There are a lot of “known” issues, but a lot more “unknown” issues that should be researched, discussed and communicated. PIARC is best placed to guide this discovery process.

8.2.2 FS2 – Building Partnerships for Better Road Safety

Background Context

Road fatalities are the leading cause of death globally among young people aged 15–29 years. Every year, the lives of more than 1.25 million people are cut short. That's over 3,400 people who die each day, or 142 every hour. In addition, between 20 and 50 million more people suffer injuries, a leading contributor of disability worldwide. The burden is especially acute in the developing world, disproportionately affecting the poor and the vulnerable.

Road safety is a combined public health, economic, and infrastructure challenge, it is an issue that effects, and is affected by, a wide array of stakeholders. The past initiatives such as the Decade of Action for Road Safety and the Sustainable Development Goals (SDGs) had an objective to halve road safety deaths and injuries by 2020. However, there have been many risk factors to address – including environmental, such as vehicle design and road infrastructure; and behavioural, including speeding and distracted driving.

Topics

The session focused on the importance of stakeholders working together; in order to accomplish the tripartite goal of creating safer roads, safer road users, and safer vehicles, with a strong focus on low-middle income countries.

Conclusions

The technical findings from the range of presentations included:

- Governments both at the local and national levels, supported by the various stakeholders and agencies, are continuing to work to improve infrastructure, create policy and laws, ensure enforcement, and educate the public about road safety issues.
- Civil society, including nongovernmental organisations and multilateral organisations, advocate for and support similar activities, while universities conduct research to understand and evaluate the issue more comprehensively.
- Society-at-large plays a role by adopting safer behaviours and demanding safer conditions, and business works individually and collectively to produce safe vehicles, safety products, engage communities, and take part in policy dialogues.
- Many learning and knowledge products have been developed including websites, reports, new material on guidelines, and courses, which vary enormously from very technical papers on in-country road safety management, to managing national planning processes.
- While it was noted that a great deal of work has been done in addressing the road safety matter, significant involvement from all stakeholders will be required to further improve road safety and reduce fatalities on our roads.
- The challenge remains that although data relevant to road safety are collected every day in most countries, for these data to be useful for informing road safety practice, they must be properly coded, processed and analysed in a computerised database system.

The key conclusions for decision makers within the industry are summarised as:

- Any actions taken by countries to prevent road traffic injuries should be based on sound scientific evidence, and should be culturally appropriate and tested locally.
- Reliable and accurate data is essential to raise awareness about the magnitude of road traffic injuries, and to convince policymakers of the need for action.
- More data is also needed to correctly identify problems, risk factors and priority areas, and to formulate strategy, set targets and monitor performance.
- Ongoing, data-led diagnosis and management of the leading road traffic injury problems will enable appropriate action and resource allocation.
- The growing amount of evidence for road safety interventions, will help decision makers implement policies and solutions that are proven to be effective, ultimately furthering the goals of the Decade of Action.

The overarching conclusions for PIARC and other international organisations included:

- International cooperation is essential for data coordination and benchmarking.
- International support can help to identify and monitor national road safety issues, as well as to evaluate the effectiveness of any methods implemented on a wider scale.
- Benchmarking (through a comparison of safety performance with similar peer countries, regions, cities, etc.) can lead to the identification of road safety issues that need to be addressed.
- Strategic coordination will help countries and governments to improve their road safety data quality and collection systems.

8.2.3 FS3 – Road Infrastructure Resilience – What does it mean and how resilient are we?

Background Context

Resilience is a transversal subject all over the world in today's society. Improving infrastructure resilience is a common concern, with the most basic premise being to reduce the probability of failure, reduce the consequences of failure and reduce the time to recovery.

Critical to this area of study is the question of how best to measure and assess resilience. Whether it relate strictly to robustness, redundancy and restitution, or alternatively, from a perspective of preparation, recuperations and adaptation.

In addition, there is currently a noteworthy paradigm shift within the industry of how the issue of disaster management is being addressed, which is impacting on the contribution of improved infrastructure resilience. The paradigm shift is outlined below for context associated with this topic.

Old Paradigm	New Paradigm
Emergency response	Risk reduction
Reactive/Responsive measures	Proactive/Preventive measures

Centralized management	Decentralized management
Role of Government	Role of all stakeholders

Topics

The individual presentations within this session covered a wide range of the fundamental concepts associated with resilience, including vulnerability assessments, disaster mitigation methods, climate change and the associated adaptation requirements and sustainable development.

Conclusions

The technical findings from the range of presentations included:

- The impacts of major disasters and climate change are spreading from local to global levels.
- Resilience plays an important role not only in the maintenance and operation of road infrastructure and road networks, but also in the planning, design and construction.
- Various factors such as natural and man-made disasters, extreme weather, climate change, and aging of infrastructure assets significantly affect road infrastructure and its function.
- The number of severe disasters and extreme weather events have been increasing in both developing and developed countries.
- The aging of infrastructure is steadily progressing everywhere in the world and technological innovations for improving infrastructure resilience is progressing very fast.
- Highways generally comprise of a network that is connected to wider transportation networks such as rail, boat and aviation. Subsequently, road infrastructure functions as itself, as well as a component of other multi-faceted networks.
- Big data and social networks provide a promising information source for resilience study and management. The amount of information that can be obtained is huge, but the information varies very much in quality.

The key conclusions for decision makers within the industry included the following:

- It is suggested that decision makers should pay attention to the rapid changes in the environment that may affect infrastructure resilience and react promptly to this progression.
- It is necessary to consider not only functions as a single component but also functions as a system when discussing infrastructure resilience.
- It will be necessary to study how to process huge amounts of information acquired from big data and social networks efficiently in order to extract the necessary and accurate information for resilience management.

The overarching conclusions for PIARC and other international organisations included:

- It is difficult for a single region or country to accumulate knowledge and experience to respond to major disasters because of their low frequency of occurrence. Subsequently, it is recommended that PIARC pursue closer collaboration with other international and regional organisations in roads

and road traffic such as REAAA, DIRCAIBEA, FEHRL, TRB, ReCAP and the World Bank, in order to collectively get a grip on the scale.

- In addition, particular attention should be paid to the dissemination of knowledge and information on improving road infrastructure resilience and sharing road authority experiences.

8.2.4 FS4 – Sustainable Pavements: On the Road to Climate Resilience & Energy Efficiency

Background Context

Global commitments to reduce carbon emissions and simultaneously increase the resilience of critical infrastructure to extreme weather events have placed greater societal expectations on road builders to design and deliver sustainable pavements that are both affordable and scalable.

Technological responses – and the associated decision support tools – are available to deploy tested and proven solutions with demonstrable benefits in a relatively short time frame. These include high-quality pavement materials with life-extending additives and green pavement technologies such as recycled asphalt materials which combine to offer road agencies a powerful toolkit of energy & environmental performance enhancement mechanisms.

Topics

The individual presentations within this session presented a comparative benchmark of the state of readiness of the most promising pavement technologies, as well as endeavouring to achieve a high-level consensus on the political and financing framework required to operate the transition from prototypes today to large-scale deployment tomorrow.

Conclusions

The technical findings from the range of presentations included:

- Knowledge, scientific data and technical guides on improved road materials and construction processes are becoming more prominent around the world.
- Modern asphalt rubber mixtures have been tested to deliver improved permanent deformation and fatigue cracking whilst providing a much-needed recycling outlet for end of life tires.
- Sustainable pavements and construction practices are well defined and laboratory testing capabilities and modelling techniques are well established.
- A range of pavement test sections of modified materials have been installed and some are being planned for near future installations.

The key conclusions for decision makers within the industry included the following:

- Decision makers need to make bold moves on accepting “change”, promoting “innovation” and providing a platform for implementation.

The overarching conclusions for PIARC and other international organisations included:

- It is recommended to invite the authors of this session to form a sub-committee on sustainable pavements implementation strategies; and

assign the sub-committee the task of developing a work plan for short and long-term sustainability goals in the region, and to work with international experts in order to get them engaged in this effort.

8.2.5 FS5 – Sustainable Financing for Transport Infrastructure

Background Context

The PPP model is being challenged worldwide. The cradle of the PPP recently abandoned its PFI programme and is at present in a consultation process as to what the future of private finance for infrastructure should be. A stream of negative reports from different national courts of audit in Europe and peer reviewed research has fundamentally questioned the performance of the model.

Recent work by the ITF clarified two fundamental points on which the model could be challenged. Firstly, in the bidder selection process, the uncertainty suppliers (Contractors) are faced with leads to very high contingencies being applied. Secondly, due to the very long contract horizon, commonly lasting two decades or more, unexpected circumstances typically lead to an inevitable need to renegotiate the Contract.

Topics

The individual presentations within this session explored a range of angles around the central topic, primarily via detailed case studies, which honed in on the deficiencies of the current mechanisms and the potential solutions to achieve improvement.

Conclusions

The technical findings from the range of presentations included:

- Merely establishing the standards does not immediately change the past culture of doing business between the public and the private side. Subsequently, pursuing a PPP before a certain level of maturity has been reached will be challenging.
- Capacity building on the public side and pursuing the PPPs for the right reasons (not because they allow the push of debt off the balance sheet) remains to be a very strong challenge.
- However, PPPs do perform very well in terms of assuring consistent service levels at the operations and maintenance stage.
- PPP's are also very amenable to absorbing upgrades that contribute to better environmental impacts of roads as well as safety. Subsequently, high safety and environmental standards can be achieved in developing countries.
- Part of the successful delivery lies also in the engagement of the private partners with the local community and local industry, ensuring buy-in from a wider range of stakeholders. A major challenge in this case is convincing the governments that pursuing sustainable development goals matter for the local economy and more widely.
- Greater transparency in terms of reporting of the private partners, and a move towards a variable concession length (acknowledging that the private sector cannot manage the road traffic risk well) with a capped IRR is required.

- The evolution of contracting and contracting standards shows the long path that needs to be travelled before one can even consider more advanced contracting arrangements.

The key conclusions for decision makers within the industry included the following:

- Procurement capacity on the public side remains an issue and should remain subject to improvement.
- Efforts to fund infrastructure should be shared by all parties to make it sustainable and ensure that it is maintained appropriated.
- Demand risk should not be fully transferred to the PPP in road concessions as concessionaires cannot manage it – variable concession length should be the preferred choice if the state wishes to spread the demand risk.
- In PPPs (or DB) contracts the state (government) should pursue the development of a fully costed reference design and invest in other necessary studies to reduce the uncertainty bidders face when pricing risk.
- Revenues from PPPs sections that are shared with the state (government) should be pooled in a road fund to allow an extension of the road network in pursuit of social goals (safeguards will be necessary to not abuse the road fund).
- The risk spreading but also the social dimensions of the road network require funding independently of traffic, and should therefore be the result of a joint effort by the Road Administration and users.
- It was highlighted that funding should not only cover the construction aspects, but also the maintenance of the road network, as the necessary budgets grow proportionally to the network.
- Pre-funding of detailed studies before contracting new investment in existing concession, so as to reduce the uncertainty for the concessionaires and improve the risk pricing, i.e. Value for Money.
- When governments consider private finance involvement on a network scale, the RAB model should be considered as an alternative to PPPs. It already includes the cross-funding requirement, transfers less uncertainty to the private side and in consequence also requires a lower IRR.

The overarching conclusions for PIARC and other international organisations included:

- International organisations should work in collaboration to incentivize developing economies to adopt SDG requirements, when procuring infrastructure.

8.2.6 FS6 – Sustainable Urban Freight Transport: New Opportunities & Challenges

Background Context

One of the major problems for cities in their quest for attaining sustainability is urban freight transport. However, city planning is generally focused on passenger transport. Freight is primarily a business-to-business industry and the cities' efforts to address the impacts are often limited to urban and traffic planning. Consequently, approaches to achieving sustainable urban freight transport (SUFT) have to go beyond strategic city planning.

Topics

The individual presentations within this session focused on the promotion of efficient and environmentally friendly urban freight transport, including the main opportunities and challenges for sustainable urban freight transport associated with economic, environmental, safety and security issues. As well as the smart solutions for tackling the complicated problems of urban freight transport, using innovative technologies such as ICT, ITS, IoT, big data, AI, robots, and autonomous vehicles.

In addition, it importantly addressed the collaborations among stakeholders who are involved in the urban freight transport, such as public-private partnerships and the role of public sectors in the partnerships, as well as data and resource sharing between competitive freight carriers.

Conclusions

The technical findings from the range of presentations included:

- There is general consensus regarding the current challenges in urban freight transport, such as increasing freight number of trips, missing space for loading/unloading, pollution, secure traffic safety, lack of space for logistics facilities, high costs for last mile transport.
- Digitalisation is an important mega trend in the logistics and transport sector and smart approaches should make use of the new opportunities as ICT, ITS, Big Data and Internet of things.
- More advanced technical solutions such as driverless vehicles, artificial intelligence and underground transport systems are under development and partly in a testing stage.
- Besides technical solutions, it is also important to think about other measures including land-use regulation, infrastructure provision, and cooperation. More integration between passenger and freight transport is needed.
- Sustainable urban freight transport is important for balancing the economic growth and the environmental friendliness for sustainable and liveable cities.

The key conclusions for decision makers within the industry included the following:

- The application of innovative technologies, including ICT, ITS, IoT, big data, AI and robotics will be essential to achieve sustainable urban freight transport.
- Public-private partnerships (PPP's) among stakeholders who are involved in urban freight transport is required to carry out sharing of data and resources, as well as developing, implementing, and evaluating policy measures.
- It is important that cities and regions develop urban freight strategies, separately as well as part of an overall transport and mobility strategy.
- The integration of urban freight transport planning and land use planning is critical for minimizing the risk of logistics sprawl in urban areas.
- Collaboration plays a crucial role for the implementation of urban freight solutions. Stakeholder involvement is needed to reach joint and feasible solutions.

- The role of city authorities is to provide suitable framework conditions for an efficient and more ecological urban freight transport.

The overarching conclusions for PIARC and other international organisations included:

- Future studies are needed on sustainable urban freight transport focusing on the application of innovative technologies including ICT, ITS, IoT, big data, AI, robots, and autonomous vehicles, since these new technologies are developed and deployed very rapidly and are effective in creating smart urban logistics for sustainable and liveable cities.
- Future collaborations are needed with international organisations such as OECD, TRB, ITS World Congress, POLIS etc. for collecting best practices on innovative solutions for sustainable urban freight transport.

8.2.7 FS7 – Transport is not Gender Neutral: From Increasing Mobility to Enhancing Employment

Background Context

Women represent the largest share of public transport users around the world, yet they face many barriers that limit their mobility. However, some 80% of women are afraid of being harassed in public spaces. In developing countries, safety concerns and limited access to transport reduce the probability of women participating in the labor market by 16.5%, with serious consequences on the economy.

Women and men have different mobility needs and patterns, yet transport policies for most countries remain unrelentingly gender-blind. However, female participation in the transport sector—as operators, drivers, engineers, and leaders—remains low. As a result, the transport industry remains heavily male-dominated, which only makes it harder for women service users to make themselves heard, and limits incentives for the sector to become more inclusive.

Topics

The panel session showcased the importance of road infrastructure and the construction industry in bringing better connectivity to women. Understanding that the needs and challenges for women and men are often different, the session showed the importance of design and planning for roads considering gender as an important indicator of travel needs and behavior.

Conclusions

The technical findings from the range of presentations included:

- When users have to decide which mode of transport to use (private car, public transport, cycling, walking, etc.), gender is often a more robust determinant than age or income.

The key conclusions for decision makers within the industry are summarised as:

- Road Agency authorities must do their duty to enhance the accessibility to economic opportunities and services for women, of which road infrastructure plays a significant component.

8.2.8 FS8 - Implementing Research on Innovative Road Technologies: The role of the Private & Public Sector

Background

There is currently a transformation in the role and types of involvement of the public and private sectors within the area of Transport Research and Innovation activities (TR&I). This transformation consists of an increasing involvement and influence of private sector and a receding influence of corresponding public sector involvement. However, this trend is not uniformly observed across the whole transport sector.

It is most pronounced in the vehicle manufacture and transport operation areas - especially regarding electric and autonomous / connected mobility. It is not at all pronounced in the areas of deployment of research for road infrastructure, safety, and maintenance. In these areas, legacy systems continue to dominate the scene and any TR&I efforts originate mainly from the public sector. The same is true for the “public service” related types of innovation such as those related to the implementation of research relative to CAVs and the sharing economy.

Innovations, to support infrastructure and the operation of entire road systems in terms of improving operations and safety through the introduction of centralized control functions and real-time feedback to individual units (automobiles) moving through traffic corridors, are of immense importance. Road safety and even congestion, could become a problem of the past, as vehicles may collectively and remotely be slowed and optimally spaced in accordance with highway conditions.

While there is a significant amount of research currently underway in the areas of connected and autonomous vehicles and the impact of the sharing economy, the benefits of connectedness through governmental intervention may further compromise individualism and privacy, setting the stage for cultural conflicts between consumers and companies investing in automated (autonomous) vehicles.

In these transformative areas, the role of the private sector in forming, financing and leading innovation rather than depending on direct public investment to fund TR&I, needs to be investigated and discussed. These issues are already one or two decades old, but now are most evident in almost all areas of innovation activity and more so when revolutionary innovation is involved. The extent of this transformation differs from country to country and from continent to continent but there are significant transnational similarities.

When it comes to vehicle and equipment manufacturing, innovation evolves in a context of global competition and performance-related regulations. In the other domains, legacy systems as well as cultural and regulatory impediments, prevent the establishment of rigorous and sustainable private sector innovation and thus innovation production remains at a relative disadvantage. Between the various countries there are serious disparities as regards the amount of national research and development and the level of transformational innovations that are finally produced.

Also, as private firms are increasingly developing the capabilities to focus on TR&I investment, the role of government is switching from *investor of first resort* to a *guarantor of sustainability* by providing the supporting environment for the private sector to act and invest and by ensuring that innovation ecosystems have healthy market places with an expanding base of consumers to supply.

Actually, the role of the government in promoting consumption through various types of tax incentives and standard-setting is every bit as important as directly investing in innovation. Sufficient, sustained consumption provides the critical feedback necessary to energize innovation ecosystems over time. If consumption is insufficient or missing, innovation will quickly become overwhelmed and grind to a stop.

Topics

The individual presentations within this session centred on discussion and debate on the changing roles of the public and private sectors' involvement in funding and supporting of research and post-research activities for the implementation of innovative policy, organisational and administrative solutions related to road infrastructure, safety, and maintenance on one hand and Connected and Autonomous Vehicles (CAVs) on the other hand.

The deployment of research for road infrastructure, safety, and maintenance and the implementation of research relative to CAVs and the sharing economy, were the two areas of focus.

Conclusions

The technical findings from the range of presentations included:

- Technology is set to transform all forms of transportation, in particular the road sector. Autonomous and Connected Vehicles are the last example of the extraordinary evolution of innovation in the field of vehicle and equipment manufacturing.
- With the ongoing research in innovation and technology there is an increasing involvement of the private sector and a receding influence of corresponding public sector involvement.
- Furthermore, there is a context of global competition among vehicle manufacturers and the race for innovation is natural.
- In the areas of deployment of research for road infrastructure, safety and maintenance the public sector and legacy systems continue to dominate the scene because of the lack of a global competition and because not all countries are aligned in their regulatory framework.
- The majority of road authorities don't operate in a context of competition and don't use market revenues but national grants. Thus, innovation progression can remain at a relative disadvantage.

The key conclusions for decision makers within the industry included the following:

- In this context of digital revolution, connected and autonomous driving poses new challenges to the road infrastructure sector. The roads of the future have to be smart, safe, connected, equipped with the most advanced technologies.
- The public and private sectors must be able to work together in order to achieve innovation through incentives, research, funding, a simplified regulatory framework and implement these new technologies in order to enhance road safety and security, save money and time, minimize the impact on the environment and as a result connect vehicles to infrastructure for the road user.

- The role of the Government in promoting consumption of new technologies through tax incentives and standard settings is as important as directly investing in innovation.
- The road authorities need to communicate with private companies in order to select, through public procurement, the best solutions for the road users.

The conclusions for PIARC and other international organisations included:

- There is a need for a coordinated approach, good cooperation and a steady dialogue by all stakeholders from the public and private sector, and one of best places for this dialogue, for this exchange of technical knowledge, is PIARC, where representatives of public and private sectors can exchange experiences, know-how and information in order to better address together the challenges of the future and ultimately reach innovative technologies in each of our countries.

8.2.9 FS9 – Disability Inclusive Road Transport

Background Context

Inclusive road transport that enables independent travel provides a unique opportunity to change the lives of the 1 billion people in the world who live with a disability and the one in four households affected by it. This has a significant impact both on the economic and social life chances of the individual and their families and also on economic prosperity at national and international levels.

Topics

This session highlighted the economic and social benefits of disability-inclusive road transport, and the solutions to harness these benefits based on good practice and experience from around the world.

The session comprised two parts; the first session dealt with the economic and social imperatives of accessibility. The key focus centred on how social development can be positively impacted by accessible roads and how this could be achieved. The second session dealt with meeting challenges and finding solutions with the key focus on highlighting how the economic benefits gained from inclusive roads exceeds the cost of building safer and inclusive roads.

This particular session was voted the **Best Session** of the Congress out of the full programme of sessions presented over the week.

Conclusions

The technical findings from the range of presentations included:

- Developing national accessibility standards will support the adoption of universal design into national policy frameworks.
- Inclusion should be understood in terms of its economic benefit, not the economic cost. Governments will see an increase in GDP and a reduction in the burden of social benefits if greater numbers of the population can access education, healthcare and employment.
- Gathering accurate data on road traffic crashes including the number of crashes and the impact for survivors (i.e. life changing injuries informs decision making).

- Accessible roads can positively impact core areas of social development including poverty eradication, productive employment, and social inclusion leading to reduced inequalities.

The key conclusions for decision makers within the industry included the following:

- Where possible, decision makers in low income countries should be looking to leapfrog the learnings experienced by the high- and middle-income countries regarding how technology can be harnessed for the benefit of all travellers.
- All professional staff involved in the design and delivery of road transport should understand the basic principles and techniques of inclusive design. Academic institutions and professional associations can play a role in making this happen.
- With the number of older people expected to double over the next 40 years and accessible road networks essential to support growing accessible tourism industries, road authorities ought to focus on universal design to ensure that roads, road networks and transport systems lead to more accessible education, healthcare and employment for all.
- Inclusion should be incorporated within relevant legislative frameworks and fed through into policy thinking, development and delivery, with steps taken to ensure the legislation is enforced. Under the Sustainable Development Goals (SDGs), all countries and stakeholders are required to be committed to providing access to safe, affordable, accessible and sustainable transport systems for all by 2030 (SDG11).
- When road and transport systems are being designed, the needs and journeys of all potential road users must be considered as part of this process. This includes those that may currently face barriers that prevent them from travelling. In order for this to be done effectively, those designing road systems should be trained on how to design inclusive infrastructure.
- There is a strong business case for inclusive road transport. Building inclusion into infrastructure is more cost effective than retro-fitting it later. Making this explicit should significantly influence decision making.
- Road engineers should switch focus to all road users – the “pavement” should be from building to building not gutter to gutter, ensuring that the safety and accessibility of pedestrians, cyclists and other users are also considered.

The overarching conclusions for PIARC and other international organisations included:

- Work towards a common definition of “disability” so that data and statistics are comparable. There are many different types of disability and equal focus should be given to those with invisible or hidden disabilities as are given to those with physical disabilities.
- The gathering of accurate data on people with disabilities including type of disability, transport patterns, as well as the data from road traffic crashes can inform decision making in a meaningful way. Disaggregation of data by type of disability, as well as gender, will help to ensure road transport is designed to meet the needs of disabled users.

- Disability inclusive road transport should not be considered a niche issue. Steps need to be taken to mainstream consideration of the needs of all users throughout all road transport thinking particularly as transport evolves (i.e. connected and autonomous vehicles, on-demand and ridesharing services, etc.).
- It was universally agreed that further, and greater, focus needs to be given to the issue of disability inclusive road transport. The session organisers and participants highly recommended that PIARC embed the consideration of disability issues throughout their work so that messages on the importance of this are promulgated through to WRA members. The session organisers would be pleased to support and assist PIARC to develop such an action plan to ensure it is implemented within the current 4-year cycle.

8.2.10 FS10 – Connected & Autonomous Mobility: Is our Road Network Ready?

Background Context

Mobility services are expected to undergo spectacular changes within the next two decades with the introduction and widespread use of connected and autonomous vehicle (CAV) technology. However, the transition phase from human driving to self-driving will be gradual, requiring incremental interventions on the physical and digital road network to allow it to cope with mixed vehicular traffic.

With Level 3 autonomy equipped in cars currently under production, there is good reason to believe that self-driving functions are not far away to being integrated within our road network systems. Whilst various automakers have made predictions on the year, they will begin mass-producing self-driving vehicles, these typically do not factor the speed of required regulations in such areas as vehicle licensing, driver / manufacturer liability, cyber security, data protection, etc.

Topics

This session highlighted the following core issues:

- Facilitating and accelerating connected and automated driving.
- Transport models for the coexistence of automated and conventional vehicles.
- Preparing vehicles for mixed vehicle traffic flows.
- Transition area for infrastructure assisted driving.
- Case studies

Conclusions

The technical findings from the range of presentations included:

- The increased market share of point-to-point trips may actually increase congestion leading to travel times as much as 15 percent higher than the current baseline.
- Absent supply side and demand management strategies, such as repurposing HOV lanes or introducing congestion pricing, an absolute increase in vehicle miles travelled would exacerbate today's urban and interurban mobility issues.

- There are still underlying challenges for CAV technology to handle every driving task accurately and safety, particularly in complex urban conditions. One major obstacle resides in the sensors' recognition capability, particularly when the object is partly obscured; when the weather is poor; or when it is difficult to tell the structure of an obstacle.
- How CAVs will read traffic signal and signs precisely remains a fundamental problem to solve. During the transition phase, machines have to rely on image recognition and learning algorithm to perform tasks with a similar degree of accuracy to human drivers.

The key conclusions for decision makers within the industry included the following:

- In a context of unclear transition to partial and full autonomy, governmental bodies are encouraged to consider a flexible approach to the regulations surrounding infrastructure adaptation to Connected Vehicles particularly where design & traffic control manuals (MUTCD) are concerned.

The overarching conclusions for PIARC and other international organisations included:

- Considerable opportunities exist to promote international collaboration and exchange of results in this fast-changing field. PIARC's new Taskforce on Automated Transport is encouraged to remain current on cooperative research programmes and industry innovations.

8.2.11 FS11 – Rolling out BIM for Highways

Background Context

BIM has been widely implemented for building projects and is a set of technologies, processes and policies enabling multiple stakeholders to collaboratively design, construct and operate a facility in virtual space. But for those dealing in designing Roads and highways, it's slightly a new concept and process to understand. However, BIM is extremely important and relevant when it comes to infrastructure.

BIM benefits are not just limited to 'building projects' but it helps infrastructure projects as well and with the same severity. It increases collaboration and serves as a rich informative model with coordinated and reliable data of the concerned project's design to operational phase.

Topics

This session highlighted the following core issues:

- BIM and asset management systems.
- BIM as an enabler of highway projects and service delivery efficiencies.
- Benefits from structured and unstructured data for asset management.
- Case studies show casing the implementation of BIM.

Conclusions

The technical findings from the range of presentations included:

- BIM implementation needs to be standardized for ease of implementation and sharing. This is important as asset management is becoming more and more data driven, the data is coming from a variety of different sources.

- Data is a valuable asset; it is not just a tool for cost efficiency.
- A BIM model will provide a single point of truth to the owners of the asset. It will also include what if scenarios and simulations which will save in the tendering process.
- BIM modelling can be used across all life cycles of an asset (design, construction, and operation and maintenance)
- The software that supports asset management systems is wrongly called asset management system (AMS). AMS consists of a database and applications that supports decision making process. The database of AMS comprise a representation of physical assets and their history (temporal database)
- No single standard for structuring all data exists. Building a single model for all the assets doesn't work.
- The efficiency of BIM depends on the number of people using it. It is most efficient if everybody is using it so collaboration would be the easiest.
- The AIM of commons (public properties) should be accessible to everyone. This is a regulatory concern.

The key conclusions for decision makers within the industry are summarised as:

- To achieve information management maturity, focus needs to be on the four areas below:
 - Establish standard level policies and processes.
 - Identify and execute capacity building activities.
 - Improve people collaboration and skills.
 - Deploy standards-based data management tools and techniques
- In order to expand the utilization of BIM in the operation and maintenance stage, the following points should be considered:
 - Consider which information is required based on the needs of those who will operate and maintain the asset.
 - Differentiate between information that need to be modelled in 3-D and those that don't require such efforts.
 - Obtain the necessary information at the appropriate timing.

The overarching conclusions for PIARC and other international organisations included:

- Promotion of BIM models in the operation and maintenance life cycle beyond the typical design stages.

8.2.12 FS12 – Good Governance & Anti-Corruption and Response Measures (Including the Development of a Culture of Transparency & Accountability)

Background Context

Good governance, or its absence, has concerned transport sector policy makers and stakeholders for decades. The sector contributes greatly to poverty reduction

and economic growth; and billions of dollars are spent on improving and rehabilitating transport infrastructure around the world.

Despite considerable investment and much associated effort to build supportive technical, financial and management capability, however, performance in many countries lags behind expectation. 'Poor governance' is often cited as an underlying reason, the concept encompassing a range of shortcomings from weak leadership to outright corruption. Good governance can be characterised as: participatory, consensus-oriented, accountable, transparent, responsive, effective and efficient, equitable and inclusive and following the rule of law.

Conclusions

The technical findings from the range of presentations included:

- In France, AFA, the French Anti-Corruption Agency, was created in December 2016. It comprises two divisions, one for advice, strategic analysis and international affairs, and one for inspection. The first one is working in close cooperation with the private sector to better inform their documents and recommendations.
- Training is being developed in South Korea for Contractors in the field of transparency and the fight against corruption, as well as associated measures, in liaison with the Ministry of Land, Infrastructure and Transport.
- New measures are being adopted in order to ensure that Contractors consider the issues of gender-based violence and sexual exploitation and abuse.
- Investors, be they development banks, commercial banks or private investors, are getting increasingly concerned with a country's global approach to the management of issues, including transparency.

The key conclusions for decision makers within the industry included the following:

- Collective and cooperative risk-based approach actions are required.
- No one can make it alone, and collective action is required to build trust between governments, the private sector and business associations like CICA and CESA, and the civil society.
- Transparency is just one building block of a global improvement in management. Transparency issues should therefore not be considered in isolation, but together with other issues, namely health, social, safety and environment issues.
- Risk assessments are the basis for better management in these fields.

The overarching conclusions for PIARC and other international organisations included:

- It is a recommendation for PIARC to try to attract a greater number of LMICs into their Technical Committees, as well as to a broader base of countries themselves (especially those in dire need of financing for infrastructure).
- A greater focus on how the various stakeholders in the life of a project should assess and mitigate risks, from early design, right through to implementation.

- And low- and middle-income countries should be more involved in such management issues.

9. Special Project Sessions

9.1 Introduction

Each four-year cycle, PIARC pursue a range of what is categorised as Special Projects. Special Projects are a facility to pursue important topics outside of the strict framework of PIARC technical bodies. They enable the organisation to outsource the development of high-level, short documents that respond to critical issues identified by members, as and when required.

The Congress' Special Sessions are an opportunity to present important and newly emerging topics that have not yet been addressed by PIARC's Technical Committees, Task Forces or Strategic Direction Sessions. They aim at being forward-looking, broadening, and giving concrete examples of solutions and directions that are relevant for the audience.

The five strategic projects for this Congress included the following:

- **Project 1**
 - Unpredicted Infrastructure Failures
- **Project 2**
 - Unmanned Aerial Systems (Drones)
- **Project 3**
 - Positive Energy Roads
- **Project 4**
 - Contribution of Road Transport to Sustainability and Economic Development
- **Project 5**
 - Electric Road Systems

Special Projects Sessions are designed to consolidate the relationship between PIARC and other international and regional organisations who are active in the field of road and transport.

9.2 Scope

9.2.1 Project 2 - Unmanned Aerial Systems (Drones)

Background Context

Unmanned Aerial Vehicles (UAVs) promise a low cost means to achieve a "bird's eye view" and a rapid response for a wide array of transportation operations and planning applications, including incident response, coordination among a network of traffic signals, traveler information, emergency vehicle guidance, and measurement of typical roadway usage. However, many obstacles to operational use exist, including ambiguous and sometimes prohibitively restrictive government guidelines and liability concerns.

Topics

This session highlighted the use of unmanned aerial systems to remotely collect data for a range of road infrastructure applications.

Conclusions

The technical findings from the range of presentations included:

- The amount of data collected is huge (in Giga Bytes), some organisations have expressed concerns with storing this data, anticipating more data to be collected in the future.
- Lack of standards and specifications in the current guidelines within road administrations - also needs to be addressed in order to use UASs to their full potential.
- One of the biggest concerns from regulatory authorities is the safe use of UASs in public areas. Although the current generation of UASs have Obstacle Avoidance systems to prevent crashing into structures, a system that is capable of preventing a crash in a situation where UASs lose control can greatly reduce the risk to public.
- Some low end UASs have limited flight time, varying from 15 to 30 minutes, reducing the level of overall efficiency. A longer battery life will certainly improve the overall efficiency.
- The potential to increase safety, improve the effectiveness of data and the quality of roadway projects can all be positively affected by the use of drone technologies.

The key conclusions for decision makers within the industry included the following:

- It is recommended that investment in drone technology applications and standardization not only continue, but increase. This should include conducting research, developing applications and implement policy.
- More extensive studies need to be done over a diverse region to validate the performance in terms of accuracy and efficiency.

The overarching conclusions for PIARC and other international organisations included:

- The potential for the application of drones in monitoring, assessing, inspecting and similar operations is substantial. Leaders in PIARC and other international organisations are encouraged to continue to develop applications and routinely share their experiences with others in the community of practice.
- This continued knowledge exchange should efficiently promote the development of safe, effective and useful policies and procedures for the implementation of drones on a wider scale

9.2.2 Project 3 - Positive Energy Roads

Background Context

The need to reduce emissions of greenhouse gases remains a dominant issue in the debate on how transport systems shall be planned, developed and implemented. There are ever greater demands from a growing list of stakeholders to diminish the climate effects of transport systems and to phase out fossil fuels.

It is likely to assume that electric vehicles will play a major role in the future of transport systems. The limitation for now is predominantly the battery range. One potential way to overcome this is the development of electric road systems (ERS) that charge the vehicle while in motion. There are a growing range of such

technology types currently undergoing trials, in some form, around the international network, with revolutionary consequences just around the corner.

Topics

This session highlighted the conclusions of the special report prepared in late 2018, with the added context of three case studies from different countries showcasing their work and learnings.

Conclusions

The technical findings from the range of presentations included:

- There is a lot of information regarding the range of different techniques, however, testing has been completed primarily on short stretches only.
- ERSs can play an important role in achieving climate protection goals within the traffic sector and reducing greenhouse gases – however an increased degree of awareness is necessary.
- Additional benefits include improved air quality, energy efficiency, energy diversity, energy security and the enablement of new technology.

The key conclusions for decision makers within the industry included the following:

- Reduction of greenhouse gases, fossil fuel and pollutants can be achieved in one (relatively) simple solution.
- Decision makers are recommended to be aware of and work through solutions for the following:
 - Electromagnetic compatibility
 - Inter-operability all vehicles
 - Visual pollution
 - Risk of failure (for catenaries)
 - Massification
 - Pavement durability

The overarching conclusions for PIARC and other international organisations included:

- It is recommended that PIARC work towards technical harmonization, ensuring technical interoperability continues and is supported.
- Information exchanges in a workshop style format should be initiated at a lot grander scale in order to intersect with a broader range of participants.

10. Technical & Task Force Sessions

10.1 Introduction

The Congress' Technical & Task Force Sessions are designed to share specific activities, global status analysis, as well as major achievements of each PIARC Technical Committee or Task Force, during the four-year cycle. Moreover, these sessions will discuss topics linked to the state-of-the-art in the specific fields and will propose the future directions for the next four-year cycle (2020 to 2023) based on the strategies discussed within the Strategic Direction Sessions.

In preparation of the Sessions, the World Road Association officially called for individual contributions across the following five general and twenty-one specific themes:

- **Management & Finance**
 - TC A.1 Performance of Transport Administration
 - TC A.2 Road Transport System Economics & Social Development
 - TC A.3 Risk Management
 - TF A.1 Innovative Financing
 - TF A.2 Coordination between National & Sub-National Authorities
- **Access & Mobility**
 - TC B.1 Road Network Operations / Intelligent Transportation Systems
 - TC B.2 Winter Service
 - TC B.3 Sustainable Multimodality in Urban Areas
 - TC B.4 Freight
 - TF B.1 Road Design & Infrastructure for Innovative Transport Solutions & TF B.2 Automated Vehicles: Challenges & Opportunities for Road Operators & Road Authorities
- **Safety**
 - TC C-1 National Road Safety Policies & Programmes
 - TC C-2 Design & Operations of Safer Road Infrastructure
 - TF C.1 Infrastructure Security
- **Infrastructure**
 - TC D.1 Asset Management
 - TC D.2 Pavements
 - TC D.3 Bridges
 - TC D.4 Rural Roads & Earthworks
 - TC D.5 Road Tunnels Operations
- **Climate Change, Environment & Disasters**

- TC E.1 Adaptation Strategies / Resiliency
- TC E.2 Environment Considerations in Road Projects & Operations
- TC E.3 Disaster Management

These sessions were all prepared and chaired by the relevant chairs of the associated PIARC Committees and Task Forces.

10.2 Scope

10.2.1 Management & Finance

TC A-1 Performance of Transport Administration

Background Context

There is an influx of external drivers (trends and forces) being introduced not only from evolving economic, social and environmental regulations but also from changes in the historical customer base, the introduction of disruptive technologies and the constant political drive to deliver greater outcomes with reduced funding and resources.

In particular, disruptive technologies are major change drivers, not only to R&TA's, but also to society in general. Specifically, the development of Connected and Autonomous Vehicle (CAV) technology, will exert major impacts on the road and associated transport systems.

Furthermore, there is increasing attention and scrutiny by media and expectations from stakeholders and society that R&TA's deliver their programme and services efficiently. The development of a culture of transparency and accountability, employment of good governance and anti-corruption measures is gaining momentum worldwide.

It is these trends which are positioning the identification, development and implementation of Change Management as one of the most critical focus areas for R&TA's moving into the future.

Topics

This session was centred on the following key areas of focus:

- Frameworks for 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.
- Disruptive technologies and their impact on performance of Transport Administrations.

The key questions confronted within this session included whether the services being delivered by Road and Transport Administrations (R&TAs) are meeting the community's needs? What is currently being measured by R&TAs? Can we appropriately demonstrate the creation of Public Value?

Conclusions

The technical findings from the range of presentations included:

- Increasingly, Governments and the communities that they serve are seeking to better understand if the services that our industry is providing are meeting the longer-term strategic objectives and the societal outcomes of our citizens.
- Some common elements, such as road safety, customer service, network performance and maintenance, organisational performance and economic impacts, form the basis of Strategic Plans across agencies of all sizes. However, in some areas, particularly in the social and environmental space, we fail to provide sufficient measurement and information.
- Five recurring themes, regarding strategic planning and performance management arise regardless of the level of jurisdictional administration or complexity of the road and transport network:
 - The need to adapt to complex challenges by undertaking internal and external analysis and regular reviews of the environment, which is constantly evolving, strategy formulation and implementation including performance indicators and integrated reporting and always considering motivation and culture in the organisation.
 - Identifying the resources or inputs that we use in order to create value for the communities that we serve. Creating alignment of the six Capitals and seven Transport Key Resources for creating “value”.
 - Addressing gaps in measurement (you can’t manage what you don’t measure).
 - Focusing on key priority areas of environment, the economy, and society, to achieve a successful sustainable transportation system. While road traffic will likely always be the dominant transport mode; it should be recognised that transport modes should not compete with each other, but rather should be viewed as complementary.
 - Taking a holistic approach to achieving outcomes beyond just roads and transport. Transportation policy and strategic direction should play an integral and companion role in achieving goals in other social policy arenas and be supportive of community needs into the future.
- Performance management must be aligned with the strategic plan, but there is no “one best approach” for performance measurement and strategic planning; so the approach has to fit cultural and institutional arrangements.
- Anticipating and responding to major change drivers is helped enormously by having a conceptual framework of change management (such as the PIARC Conceptual Model of Change presented in the Session) which combines inputs, outcomes, key change steps and dimensions of change.
- Principles and guidelines for the application of the framework are also important, covering the context of change, the six core principles of change, and engaging people as key levers of change.

- Also important is the identification of key external drivers for change in the coming years, frequently interdependent. Identification of reasons for failure and critical success factors.
- Road administrations are incorporating into their strategic plan a culture of transparency and accountability. Many of them are introducing additional directives to their codes, laws or standards. However, there is not great level of awareness of international laws, regulations (such as the OECD Guidelines) or recommendations.
- There are best practice measures undertaken in the past 5 years in several countries, with impacts in the road sector in respect to better transparency and accountability.

The overarching conclusions for decision makers within the industry included the following:

- Transport and road administrations have to stop defining themselves by the assets they manage but rather by the services they deliver. They must be prepared to address not only the changing societal expectations, but the impact of new disruptive technologies as well, both of which are megatrends and drivers for change.
- Mobility is much more than a set of infrastructure assets but a vital service (mobility as a service) with increasing societal expectations and needs in a rapidly changing world.
- If you do not manage change, then change will for sure manage you. Therefore, it is not a matter of if you should plan for your change, it is when and how, because the best way to predict the future is to create it. And the best way to do that is by planning for different potential scenarios.
- All that must be conducted with transparent and accountable governance for creating trust. This is much more than a matter of compliance and ticking a box. It's a daily challenge and a matter of course.
- We must provide 4C-II (Clear, Constant, Consistent and Convincing Integrated Information) noting that it is worth investing in our sector because we perform well and create multidimensional Public Value. That's something to remind policymakers, public and media, especially when trying to maintain budgets in the face of austerity and the downswing of the economic cycle.

The specific theme conclusions for decision makers within the industry included the following:

- A well-developed strategic plan supported by appropriate and relevant performance measures will provide a better assessment to whether the services delivered are meeting long term strategic objectives and the societal outcomes and needs of citizens.
- Strategy and performance management frameworks need to be dynamic and able to respond to changing conditions.
- Information is a valuable asset. Don't only report on past performance. Progress and outcomes need to be not only measured but also reported in an integrated and consistent manner.

- Transparent and clear communication of results: a powerful tool in efforts to “tell the story”, particularly as it relates to the impacts of investment and policy decisions.
- Organisations which anticipate, plan, implement and communicate change in a comprehensive and strategic manner, understand better what success looks like and how to achieve it.
- In anticipating and responding to change, certain central factors, processes and principles can be established, but individual organisations need to find their “own way”, based on their circumstances, values and ambition, and keeping in mind the unpredictable and uncontrollable character of transformational change.
- People are usually afraid of change because they fear the unknown. But the single greatest constant of history is that everything changes (Yuval Noah Harari, Homo Deus: A Brief History of Tomorrow).
- There is a need for greater involvement of Ministries of Infrastructure/Transport along with their Ministries of Finance/Justice in order to promote transparency, accountability and fight against corruption.
- The fight against corruption should be no longer considered in isolation but as part of a comprehensive management system and part of the daily due diligence of the organisation. In this respect, collective action by governmental agencies with private sector organisations and civil society is strongly recommended.
- CAV technology, like other disruptive concepts, is subject to major uncertainties on key technical social, economic and political aspects.
- These uncertainties must be addressed through appropriate research, product development, and policy and regulatory formulation at different stages of technology maturity, development and deployment.
- CAV research and development is best enabled through Public - Academic - Private Partnerships (PAPPs), including physical and digital test facilities, but also policy development, skills building and social marketing. Such facilities are under development or have recently been launched in China, France, Italy, United States, and other PIARC member countries, with differing balance between hard (technology) and soft (policy and social) programmes.
- It is also necessary for CAV development to consider road infrastructure design, asset management and maintenance and functionality, both for new assets and legacy assets.

The overarching conclusions for PIARC and other international organisations included:

- It will be useful to better understand the customer experience and expectations and how to best communicate and share that information with them.
- Emerging and disruptive technologies will drastically alter how people view mobility, how they travel, how freight moves and what overall travel behaviour and expectations are. It is important to continue to look into the

impacts of these technologies on the performance of transport administration from a policy perspective.

- Road and Transport Administrations must understand and adopt digital solutions and business intelligence tools to better engage with employees, elected officials and the community. At the same time, they must work on capacity building through training programmes to ensure that their employees are capable of taking advantage of the new technologies.
- Climate change will become an issue in future strategies of many administrations.
- Further work needs to be undertaken to better understand how the communication of performance results is being sought by public and customers, how it should be shared and how can organisations and the community engage with it. It's also necessary to explore tools that make performance information more accessible, usable, and easier to communicate.
- A toolkit for practitioners will be useful for many Administrations that do not have experience of running a comprehensive strategical planning and evaluation process.
- Further investigation should be undertaken of specific external change drivers, including amongst others, future vehicle and smart highway technology, environmental sustainability, climate change and organisational efficiency. Particular merit on focusing on disruptive technologies and data as external driver for strategies and for the way they manage operations and customers.
- Continued areas of work related to change management include: stakeholder participation, organisational legitimacy, culture, public value and wider transport sector governance. Research should particularly a research focus on organisational culture and associated behaviours.
- Wider involvement of low- and middle-income countries is needed in the promotion of transparency and accountability initiatives: PIARC could assist in developing training sessions, ideally at international regional level. We recommend partnerships with existing organisations for joint actions on these topics
- Challenges associated with CAVs will be explored by TC 1.1 in 2020-2023 cycle, in the context of wider disruptive technologies and service models and their impact on road and transport agencies.

TC A.2 Road Transport System Economics and Social Development

Background Context

For four years, the committee surveyed a range of transport economic and social appraisals and evaluations from across the world. This session brought the conclusion of the case studies together.

However, the session looked beyond the remits of the past four years and reached out to the history and sociology of transport. In this respect, it was able to better appreciate the emerging challenges of appraisal and evaluation of road transport systems.

Conclusions

The technical findings from the range of presentations included:

- It is clear that we cannot (and should not) continue to tweak the old established models when assessing the future. The force of the fourth industrial revolution (4IR) is asking us to create new frames.
- Further, climate concerns also challenge the old models. It is a new strand.
- The old notions of value of time (VoT) and journey reliability are challenged.
- Technology allows users to be productive and to be able to engage with the broader world as they use transport.

The key conclusions for decision makers within the industry included the following:

- These emerging forces of change dictate that tweaks to the old models (based on cardinal utility) are not sustainable. The transport profession must tackle the new complexities. And the public will demand they do so.

TC A.3 Risk Management

Background Context

Our world is burgeoning with a range of increasingly complex technological advancements. Subsequently, the management of risks and uncertainties has become an essential element within the practices on a range of levels. Firstly, for road organisations and road practitioners in order to achieve the range of strategic objectives of their organisations. And secondly, to achieve smooth project development across all phases of the project's life-cycle.

Topics

The session highlighted the importance of managing, assessing and evaluating the broad range of risks within the road transport sector. Risks included natural disasters, climate change, security threats and the way that they are socially accepted. Specifically, the session presented the issues around the context of Enterprise Risk Management (ERM) and Project Risk Management.

Conclusions

The technical findings from the range of presentations included:

- ERM is best implemented in a gradual approach where you may gain experience and expertise. In this respect, a step-wise approach for implementing ERM in road organisations was proposed and presented.
- The Project Risk Catalogue presented doesn't cover all of the possible risks but serves as an inspirational, brainstorming risk identification tool in the early stages of the risk analysis process (i.e. risk identification and classification) with proposed mitigation measures that need to be kept up to date with technological developments and modified accordingly.

The key conclusions for decision makers within the industry included the following:

- Good risk management at the beginning of infrastructure project life-cycle contributes in ensuring quality during the entire infrastructure life-cycle.
- Risk management practitioners and organisations need to proactively strive for future readiness in addressing the degree of uncertainty. In this

respect, insight was provided on the steps that are needed to be able to assess future readiness by using a scenario planning approach.

- ERM may be perceived as overly challenging and expensive by senior management. However, it does not necessarily have to be. Ultimately, it should be kept simple and not overly complicated.
- ERM is both a top-down and bottom up exercise. While bottom-up oversight may create risk management inefficiencies, it is the flaws and gaps in the top-down approach that may drastically limit its effectiveness.
- ERM is a journey that represents commitment to continuous improvement.
- ERM varies in its application, with no single methodology suiting all organisations. However, principles have been standardized and are generally applicable to all. Imagination and creativity are tools in designing ERM, however, experience and expertise are required competences.
- There is further need for research on the methodologies and relevant metrics for measuring and clearly relating ERM performance and added value in achieving the organisation's objectives.

The overarching conclusions for PIARC and other international organisations included:

- The members of the Technical Committee and possibly other international experts on risk management, have identified interdependencies in achieving the organisation's objectives of asset management, performance management and risk management.
- Thus, a comprehensive framework that would jointly consider these and their potential implications to the resilience of the road network in order to meet the strategic objectives of road stakeholders, would be beneficial to the road transport community.

TFA.1 Innovative Financing

Background Context

In the last two decades there has been an increased contribution of the private sector, through some form of public-private partnership (PPP), to finance transport infrastructure in general, and roads in particular, in both the developed and developing worlds. Such contribution has helped several countries to maintain, rehabilitate and expand their road networks, including the construction of new motorways, bridges and tunnels.

Some governments have increased the public contribution to potential PPP road projects to make them attractive to private investors. Such support may take the form of grants (or subsidies) to project construction, as well as availability payments and operational grants or minimum revenue guarantees during the operational phase of the PPP project. Nevertheless, there are projects that will not be able to attract private financing and will have to be financed via other methods.

Topics

This session was centred on the following key areas of focus:

- Basic principles governing investment in road infrastructure.
- Broad ranging issues which impact on financing.

- Insight into the current global, national & regional programmes.
- Country reports, case studies & associated surveys.

Conclusions

The key conclusions for decision makers within the industry included the following:

- Pay per use should be pursued, in a range of different mechanisms.
- In respect to developing countries it is critical to increase the degree of private financing/funding and reducing the reliance on high levels of public financing/funding.
- In respect to developed countries there is high levels of private financing/funding and decreasing levels of public financing/funding.
- The achievement of major co-mobility advances requires deep financial innovations in terms of international relationships.

The overarching conclusions for PIARC and other international organisations included:

- Greater levels of attention and focus should be applied to the range of developing countries in order to avoid widespread inequality.
- Greater horizontal tasks (e.g. Global issues, regional groups, formal and informal international organisations) should be addressed.
- The strategic plans for 2020 – 2023 should focus on the following:
 - Opportunities to continue working on innovative financing.
 - Technological innovations.
 - Environmental considerations.
 - New energy trends.

TFA.2 Coordination between National and Sub-National Authorities

Background Context

The need for cooperation between National and Local road agencies is becoming much more prominent, due primarily to the growing concern that mature networks of roads must consider all roads within the network as functioning as an overall system. However, traditionally, both Regional and Local roads have been deemed the responsibility of sub-national authorities, and beyond the scope of national mandates.

The growing importance of metropolitan areas and the need to see the transport system as a whole regarding traffic safety etc., is making it necessary to look at how the different levels of government can find good practices and principles that can lead to successful cooperation and collaborations.

Topics

This session explored a range of general areas of potential cooperation, including funding, planning, prioritizing of projects, project delivery, technical standards, workforce competency and institutional interactions.

Conclusions

The technical findings from the range of presentations included:

- A range of anecdotal studies including:
 - In the U.S., the Metropolitan Planning Organisations (MPO) are federally required to represent urbanized areas with populations over 50,000 inhabitants. The planning functions are carried out in cooperation with state and local agencies, and must be coordinated, comprehensive and continuous. This is a good example of how a framework can be set up to facilitate cooperation between different levels of government.
 - In Norway, there is urban environmental agreements in the biggest cities that is set up to meet the object of zero growth in passenger car traffic. The national, regional and municipal level is represented in negotiations that adopt a project portfolio that includes investments in public transport and roads. The aim is to reduce congestion problems, pollution, noise and release areas that can be used for other purposes like urban development. This is also a model that can be used to ensure that both national and local objectives can be met.
 - The United Kingdom Road Liaison Group (UKRLG) is a forum whereby policy and research approaches are developed by practitioners in a collaborative way to improve highway maintenance delivery.
- The subnational level often has a shortage of funding and competent workforce. There aren't many extra funding possibilities for the subnational level. The subnational level is often responsible for the largest transport network, with lower traffic, but with a higher degree of traffic accidents.
- To carry out accurate analyses there is an increased demand for data. The data should be open, but there is also a need to ensure that it can't be used to illegal purposes. There is a need for standards across the different levels of government, but also a flexibility so data could be adjusted to different needs. This requires both a top-down and a bottom-up approach between the national and the local level. There must be a consistent set of data, and figures must be comparable.

The key conclusions for decision makers within the industry included the following:

- There is a need to establish an appropriate framework where national and local authorities can work together in a cooperative fashion.

The overarching conclusions for PIARC and other international organisations included:

- There is a need for cooperation and collaboration between the national and subnational level, but the papers presented showed that there is also a need to look at the international level.
- Take account of the French Road Observatory concept when considering developments with the PIARC Road Statistics product, particularly regarding disaggregation of national and sub national road data (e.g. on road condition, on bridge condition).
- Gaining an understanding of the difference in road condition between national and subnational level will help PIARC better articulate what the Task Force considers a current issue for road administrations (i.e. national

road condition is better vis-à-vis local road condition) but collating global data on this would be beneficial.

10.2.2 Access & Mobility

TC B.1 Road Network Operations / Intelligent Transportation Systems

Background Context

Obtaining maximum benefit from existing network infrastructure is a priority for many member countries. Improvements to capacity, reliability, safety, energy saving and the use of new traffic technologies and cost-effective applications are particularly important whether achieved by interfacing with other modes and/or the use of intelligent transportation systems (ITS).

Topics

This session highlighted the three central topics:

- Low cost ITS.
- Big data.
- Knowledge sharing (and capitalization of expertise on RNO and ITS).

And provided updates to the ITS/Road Network Operation Manual that was developed in the 2011-2015 work cycle, along with supporting the dissemination and implementation of support strategies.

In addition to the tradition format, the session included an interactive component centrally aimed at involving the audience, and moreover, to hear their voice. This was driven primarily by the one of the main pillars of this Technical Committee being the user in the middle. Allowing the audience to speak about present results achieved and their future expectations, was a powerful means in order to be fully calibrated with the present needs of the technical community, practitioners and young professionals.

Conclusions

The technical findings from the range of presentations included:

- It is a very important finding of the whole congress, not only of this specific session, that user behaviours need to be considered furthermore and in a different way, in order to include the audiences that have previously been cut off from the analysis, like women or children.
- “Mobility as a service” could be a tricky subject if it is not considered as a tool. It is not a magical solution for the transportation system.
- ITS traditional approach is not the only one and through this technical committee we analyzed pros and cons and identify the strategy developed countries and LMIC can put in place according to their need
- Options should not be considered as exclusive, moreover they should be combined in order to get the tailored set of results needed, according to the level of timing and effectiveness required.
- Big data in the transport sector is very different from big data in other sections (i.e. banking). A constant and continuous feed of data is required in order to adjust and always feed the system in order to continually improve and grow the number of services.

- There are many issues associated with big data that still need to be addressed (i.e. privacy issues).

The key conclusions for decision makers within the industry included the following:

- Big data is key to enable the services for road users and there is great potential to improve road network operations, however a specific set of skills are needed to be brought into the industry.

The overarching conclusions for PIARC and other international organisations included:

- The next cycle should work to a “Access & Mobility” strategic theme, covering the following specific issues:
 - Mobility as a service (MaaS).
 - New mobility forms.
 - Optimizing road operations and performances through new technologies and digitalisation.
 - Medium-level overview / insight into RNO-ITS decision makers for middle managers and young professionals.

TC B.2 Winter Service

Background Context

Winter service is a unique element of transport policy, which is relevant to roads, pavements, cycle paths and public transport sites.

Topics

The session highlighted the following central topics:

- Presentation of all activities undertaken, and accomplishments achieved throughout the last cycle.
- The current practices associated with transportation management during the critical winter months.
- Case studies of technical, managerial and organisational initiatives implemented during winter operations.
- De-icing salt and brines treatments, interventions and best practices.
- Dynamic forecast controlled winter road maintenance technologies.
- Preventive and curative maintenance using de-icing salt and brine treatments.

Conclusions

The technical findings from the range of presentations included:

- There is an absolute necessity associated in achieving strong coordination between road agencies and/or different road owners.
- The interest from road operators to experiment with brine and/ or mixes of brine and rock salt to achieve different levels of performance requirements remains strong.

- From a practical perspective, it has been reliably proven that treatments in brine, or with a liquid solid mixture, are the most effective in achieving a positive result, the cheapest and the least harmful to the environment.
- The development of these techniques requires investment and training because it may seem counter-intuitive to add water to the pavement.

The key conclusions for decision makers within the industry included the following:

- The session had an overwhelming focus on the need to ensure coordination between all of the separate, yet interacting, parties.
- For many developed countries, the question posed around winter service is not around increasing the capacity and density of the road networks, but more about the optimisation of existing infrastructure under degraded conditions, which can be considered as an adjustable parameter.
- Winter service must be considered in line with inter-modality, with the priorities between modes transport to be defined and strong coordination between different project owners and operators.
- Increasingly, road operators are having to manage networks that are almost at saturation. Therefore, it is absolutely necessary for road operators to be anticipating the weather, and subsequently the road, conditions.
- “Anticipating” means having predictive tools at your disposal that allow you to use available or forecasted weather and road weather information, based on actual or forecasted traffic counts in order to be able to make projections on the overall behaviour of traffic flows. From such forecasts, appropriate strategies and preventive interventions can be derived, as well as appropriately communicated to users.
- Most importantly, it should be stated that decision makers must be curious in their pursuit of progress. They must look at what is being trialed elsewhere and copy when the results are successful.
- A recommended approach to achieving this aim is to participate in future congresses and seminars, as well as delving into the specific literature produced (both future and historical).

The overarching conclusions for PIARC and other international organisations included:

- Beyond the latest technical or organisational developments, which are of course to be taken into account, it is important to note that the relatively simple subjects still remain topical.
- Cases in point include the coordination between different project owners, project managers and stakeholders; as well as the development of simply processing techniques.
- The evidence suggests that progress is still to be made in these relatively basic areas, and that they are still real subjects which should be studied and progressed.

TC B.3 Sustainable Multimodality in Urban Areas

Background Context

The car can be integrated into the complex structures of contemporary lifestyles like no other mode of transportation. The consequence is the emergence of highly car-dependent mobility behavior. Nevertheless, the use of multiple modes of transportation, a behavior that is desirable from the perspective of transportation policy, is a matter of course and daily routine for a not insignificant segment of the population.

However, our societies have moved in less than a century from a traditional model with two types of living environment (cities and village communities) practically independent in terms of daily mobility, to a model of peri-urbanization where hundreds or even thousands of village communities located more than a hundred kilometers from a city live in close relationship with it. This relationship translates into daily exchanges for access to employment, education, health care, or leisure.

Topics

This session highlighted three central topics:

- Multi-modal urban transportation policies and strategies.
- Road based mobility solutions (including multimodal interchanges and new road mobility).
- Land use and urban development.

Although in search of technical findings, the session identified and posed a number of relevant, topical and challenging questions for the audience. These included:

- Whether the current model of spatial occupation, consisting of a mosaic of geographically separated regions closely linked by daily exchanges, will continue to expand, stabilize or multiply?
- Since digital technology already allows remote working, are we likely to see a further dispersion of living and working areas with less physical presence in the workplace?
- Such trends will be associated with essential services (education, care, etc.) being positioned closer to living areas. Therefore, will there be a reduction in mobility needs?
- Furthermore, with the introduction of autonomous vehicles, transport costs, driver time lost and travel discomfort will all be reduced. Will this in effect drive new desires to travel further (or more often) in order to access new opportunities?
- Finally, how can we consider the challenges of climate change and the scarcity of natural resources?

Conclusions

However, two technical findings from the range of sessions included:

- The need to continue sharing observations, good practices and lessons learned at the international level, and the multiplicity of views on all of these practices.
- The need to broaden our knowledge and experience with new approaches, particularly through the social sciences.

The key conclusions for decision makers within the industry included the following:

- The focus must be placed specifically on the unique user needs, and not on any specific project objective/KPI or individual vehicle type.
- Issues must be approached from a large-scale perspective, as in, not just the area of focus but its relevant commuting areas as well.
- In order to transport with a greater degree of quantity and quality, multi-modal approaches must be progressed.
- All stakeholders must be considered in the process and coordination between all must be a priority.
- The importance in keeping abreast of the trends (e.g. future urbanisation, ageing and a sharing economy) is paramount.
- And finally, a reminder to be pragmatic yet ambitious.

The overarching conclusions for PIARC and other international organisations included:

- Under the context of increasing impacts from climate change, it is now urgent to find efficient solutions to “transport more and better with the existing networks”.
- Roads can be used effectively to achieve reliable Be-Right-There (BRT) services when connected with Mass Rapid Transit. However, there is currently not a substantial amount of case study data regarding costs and the associated benefits in order to promote these initiatives.
- Similarly, carpooling is frequently suggested, yet lacks cost and benefit data sufficient to drive initiatives.
- A dedicated commitment to sourcing an appropriate degree of such data in coordination with Transportation Research Boards (TRB's) or Universities would be very useful.

TC B.4 Freight

Background Context

In developed economies, e-commerce logistics represents the latest big driver of change in logistics and physical distribution networks, which have evolved substantially over the past 40 years or so. Currently, it remains the case that as e-commerce continues to grow, most shippers, particularly multi-channel shippers, are still only just beginning to work out what this will entail for their distribution network infrastructures.

Conclusions

The technical findings from the range of presentations included:

- That there is a common understanding that freight and logistics needs more attention in national transport and land use planning. Logistics and freight transport should be better integrated into overall transport policies at the national, but also on the regional and local level.
- For developing multimodal freight policies there is a consensus that stakeholder involvement is essential. A proper stakeholder involvement sets the stage for the acceptance by different groups and a successful

implementation of the policy. The benefits of stakeholder involvement are bigger than the associated costs.

The key conclusions for decision makers within the industry included the following:

- National freight policies should look at the optimal use and integration between different modes as this could offer an advanced platform for more efficient, reliable, flexible and sustainable freight transportation.
- National transport and road authorities should develop masterplans for logistics and freight transport in order to appropriately consider the requirements of logistics and freight in the planning of a multimodal transport system.

The overarching conclusions for PIARC and other international organisations included:

- It is recommended that PIARC member countries recognise the importance of management and operation of freight traffic on highways and motorways in order to tackle the associated issues related to broader sustainability, safety and higher efficiency transport, with the support of advanced technologies as well as management schemes.
- It is also recommended that PIARC countries address the key aspects of collaboration between the public authorities and private companies in terms of sharing data and information, as well as communicating this information between each other in order to enhance the planning, implementation and evaluation stages of policy measures for sustainable, safer and higher energy efficient freight transport.
- Finally, further research through coordinated international collaboration is needed in order to investigate the application of new technologies (e.g. ICT, ITS and LoT) specific to freight traffic on highways and motorways.

TF B.1 Road Design & Infrastructure for Innovative Transport Solutions & TF B.2 Automated Vehicles: Challenges & Opportunities for Road Operators & Road Authorities

Background Context

The deployment of Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V) communication, also known as cooperative intelligent transport systems (C-ITS) is speeding up in many developed countries. These technologies involve many opportunities for road operators both for road design and operations, but also many challenges.

Topics

The first part of the session dealt with the challenges and opportunities of connected driving (also known as Cooperative Intelligent Transport Systems or C-ITS) for road operators. The second part of the session dealt with the challenges and opportunities of automated driving for road operators, based on the intermediate results of TF B.2.

Conclusions

The technical findings from Part 1 were broken down into three components:

- Analysis of the inputs gathered

- The analysis of the 23 surveys received allowed a range of interesting statistics to be extrapolated.
- The majority of the cases study came from Europe (20), one from Australia, one from South Korea and one from Japan.
- These projects, all led by road network operators, are 80% in operation or in a trial period. The trial period was characterized by the fact that the project is deployed in a small area or the data is not yet available to the public.
- The benefits expected from the projects are grouped into the following three main families: security, mobility and the environment.
- V2I communication allows many "services" to users.
- Other services deployed in a smaller number of projects such as the priority of emergency vehicles to fire and the protection of vulnerable users are noteworthy.
- Projects use different radio communication protocols.
- ITS-G5 is widely used in Europe while DSRC 5.9 or 5.8 is used in Asia (DSRC for Dedicated Short Range Communication).
- Opportunities of connected driving for road operators:
 - In terms of opportunities for road operators, C-ITS can potentially improve road safety, traffic efficiency and comfort of driving, by helping the driver to take the right decisions and adapt to the traffic situation.
 - C-ITS can also help road design and asset management.
 - These technologies can also reduce costs for road operators or even generate revenues.
 - Regarding automated driving, C-ITS will help increase the safety of future automated vehicles and their full integration in the overall transport system.
 - C-ITS and automation are complementary technologies and will merge completely over time.
- Challenges of connected driving for road operators
 - For the deployment of services through C-ITS, the services have been established and prioritized. We can talk about services in the short term (called day 1 applications) and in the long term.
 - Business models for road and traffic operators: the wide variety of C-ITS services can be offered to road users and other stakeholders, from different suppliers, in an independently or in a collective manner.
 - Analysis of the advantages and disadvantages of the different technologies used: Short Range Communication, Long Range Communication and Wide Area Broadcast.
 - It is important to develop a common framework for the assessment of data quality that define clear processes for assessing and

reporting on data quality. Besides, the opening and sharing of such data sources among the different C-ITS players it is necessary to bring benefits.

- Security must be ensured throughout the entire service chain, from the generation of C-ITS services to the presentation of C-ITS services to the individual user. It is the responsibility of each stakeholder to ensure the security and protection of data within their own system.
- It is important to promote the safety potential and effectiveness of C-ITS services so that this service can be trusted by road users to provide safer conditions for those utilizing them. To achieve this, it is necessary for road users, the end-users of C-ITS services, to understand the available services and recognize the advantages through direct and indirect participation, and thereby encourage ongoing utilization.

In addition to the findings, a range of questions were also posed to the audience. These included:

- Noting that deploying DSRC/ITS G5 road site units requires major capital investments while governments are looking to reduce investments in road infrastructure (e.g. France has an extensive road network of over 1million km), has the task force evaluated the cost/benefit of the technology options?
 - The Task Force considered the technologies used in pilot projects: DSRC/ITS G5 is the most used. However, the report has recommended hybrid technology (use 5G or 4G if not available). Moreover, there is a French cost-benefit analysis showing that a scenario “start deployment now based on ITS G5 and hybridize with 5G once available” is more efficient than a scenario “don’t invest now and wait for 5G”.
- Has Task Force considered safety (security) of the communication equipment against vandalism, physical destruction (during protests, riots etc.)?
 - The possibilities of vandalism are low since road side units will be situated 7-10m above the ground.
- Are there linkages between the work of this Task Force and other PIARC Task Forces?
 - YES. There are linkages between TFs as Strategic Plan aligned each Task Force while Technical Sessions during WRC also enhance synergies.
 - It was noted that under the new Strategic Plan cycle, use of Big Data and CAV by RNO has been addressed and linkages among various TF to create value collectively
- Is there evidence that C-ITS will improve road safety?
 - YES. Evidence that Connected Vehicles will mitigate fatalities is available.

The technical findings from Part 2 were broken down into four components:

- Physical infrastructure:
 - The lifecycle differences between information technology equipment, digital infrastructure and physical infrastructure are one of the key issues that will challenge road network operators and as such long-term asset planning should take connected and automated vehicles needs into consideration.
 - With recognition that vehicles are manufactured for global markets, significant international efforts are needed to harmonize traffic signs and road markings to ensure consistent recognition and safety.
 - Alternatively, some jurisdictions may elect to digitize all forms of signage by adding infrastructure-to-vehicle connectivity or machine-readable code (e.g. QR code).
 - Road network operators may also consider analysis on designating lanes for vehicles with higher levels of automation or platoons which may enable the deployment of the technology while minimizing risks from interactions with non-automated traffic.
 - Notwithstanding, consideration must be given to the optimum use of road networks and public transport needs.
 - Automation has the potential to decrease vehicle headways and therefore increase road capacity, road network operators must account for pavement and bridge fatigue as well as rutting in their planning and design efforts.
- Digital infrastructure:
 - Data is one core-element when it comes to Automated driving. Hereby data is collected, transmitted, processed and analyzed to provide inputs to automated driving functions.
 - Within the session all these elements will be discussed with a specific focus on responsibilities of and tasks for the Road Network Operators.
 - Herby a link to big data analysis (including Artificial Intelligence) will be given to discuss the different kind of data.
 - In detail the challenge is, that within Road Network Operations we have to deal with various kinds of data – small and big data, static and dynamic data, data in different formats, open and closed data etc.
 - A specific focus will be given to the access to data. How is access to data, and especially to in-vehicle data handled in different areas of the globe?
 - In addition, data analysis and generation of knowledge will be an additional focus. Gathered knowledge needs to be put together in so-called high definition maps. And such HD maps are a core element when it comes to automated driving functions. The session will deal with HD map concepts and discuss the responsibility of different actors to ensure a safe and secure

operation of automated functions (advanced driving assistance systems – ADAS) within the vehicles of the future.

- Impact on RNO:
 - The emergence of automated vehicles on public roads is expected to deliver a range of operational improvements.
 - Some forecasts indicate significant improvements while other forecasts are less optimistic.
 - Recent studies suggest that in the longer term, higher penetration rates of AV's may provide some modest improvements to road capacity and utilisation, however, during the intervening period lower penetration rates may lead to reductions in operational capacity.
 - Automation and platooning of freight vehicles have the potential to improve the efficiency of road-based logistics through fuel savings and other reduced operating costs and a number of platooning trials are occurring in various jurisdictions around the world.
 - Automation also presents new opportunities for new mobility services through the integration of automated shuttles for a range of user groups.
 - Recent trials have highlighted challenges for automated vehicles to operate in mixed use environments such as zones shared with pedestrians. In addition to the difficulties associated with shuttles interacting with people, people also have varying expectations about how to interact and navigate in open spaces with automated vehicles.
 - With increasing penetration of AV's in vehicle fleets, there is an expectation that the expanded data and intelligence from connected and automated vehicles, available in real-time, will enable improved road network operational control and response.
 - Challenges exist with the availability, type and consistency of data from vehicle manufacturers to make such improvement opportunities.
 - Road agencies also need to shift the way that their road networks are operated to thoroughly leverage the available data and implement the tools and control systems that can optimise network operations.
- Social impacts:
 - The presentation will summarise the state of the art in the field of social issues connected with automated transport.
 - It will be shown, that the potential benefits of automated transport may be limited by a range of human factors issues (e.g. technology over-reliance; driver overload or underload; driver distraction; failing to trust or accept the technology leading to system misuse or disuse; loss of driver skill; adoption of risky driving behaviours) and what are the current attitudes, needs and beliefs towards automated transport.

- Based on that will be concluded possible direct and indirect impacts of automated technology on individuals and society (e.g. impact on safety; mobility; travel behaviour; public finances; emission; environment; education, etc.).
- Consequently, pros and cons of automated transport for different types of countries will be discussed.

In addition to the findings, a range of questions were also posed to the audience. These included:

- Has the Task Force considered the disruptive nature of the technology on human behavior? Are the schemes water tight? For example, police mistakenly chasing a drunk driver who is in an AV?
 - Yes. Task Force recommends that human factors must be solved mainly by the OEMs through technology and not RNO. However, more studies are necessary to identify disruptive events and build in mitigation measures.
- Happy to note that the study introduces an index of service level for RNO. However, there is need to develop a unified single index covering both Road Infrastructure and Digital Transport Infrastructure?
 - Concur that there is need for index which covers both quality of data and quality of service.

The key conclusions for decision makers within the industry from Part 1 included the following:

- The big question is “where to start?”. The experience from the various pilots all over the world suggests that it is best to start small and to learn by actually doing. Pilot deployments based on a few of the most mature services (the so-called Day 1 services) are a good start.
- Examples of technical specifications are available from existing pilot deployments. Some are already harmonized, as in Europe, to ensure interoperability.
- Security and privacy are important challenges that must be tackled with appropriate experts.
- The key point is not technical, it is to involve all relevant stakeholders. Road operators cannot deploy C-ITS by themselves, they need to work in close relationship with car manufacturers and service providers who will be delivering the service to the end user.
- Cooperative ITS’s are indeed, above all, a matter of cooperation.
- There is need to harmonize approaches/ perspectives on Road Infrastructure requirements by different professionals for example current debate on revision of the traffic signs (Vienna Convention) by Traffic Engineers and Road Safety professionals.

The key conclusions for decision makers within the industry from Part 2 were assessed as still too early in their development for circulation at this juncture.

The overarching conclusions for PIARC and other international organisations included:

- As these topics are evolving very fast, it is recommended to PIARC that they monitor the progress closely and provide regular updates across the industry.
- This will be particularly required at the finalisation of the TF B.2 (2020).
- PIARC must ensure diversity is achieved within the Task Force membership and the open communication on the relevant issues.

10.2.3 Safety

TC C-1 National Road Safety Policies & Programmes

Background Context

Road trauma is the biggest killer of young people aged 5-29 years old worldwide. An estimated 500 million people will be killed or injured between now and 2030. The United Nations has set a Sustainable Development Goal to halve road deaths and injuries and the UN Member States have now agreed 12 Global Road Safety Performance Targets to drive a step change in action over the next decade.

The PIARC Road Safety Manual provides a consolidated, on-line and up-to-date resource for all road and infrastructure professionals, transport administrations, companies and experts to access and implement. The Manual includes detailed best-practice advice on the scale of the road safety problem, the safe system approach, data needs, setting targets and monitoring progress, management accountabilities, design, construction and maintenance of safe infrastructure, intervention selection and evaluations.

A survey of 31 national government agencies has also been undertaken to capture current practice in the application of safe road infrastructure. The questionnaire included progress in relation to national legislation, policies, road safety strategies, safety management systems, road infrastructure funding regimes and initiatives focussed on Safe System outcomes.

Topics

The technical session was organised in line with the three subjects proposed for the call for papers of the congress.

The first part was dedicated to the role of infrastructure and highlighted the evolution of the road safety manual, with the results of the devoted workshop presented, along with country experiences and policies for promoting road safety and managing safe system approach from a manager perspective.

The second part related to analytical methods for road safety and concerned all facets including assessment criteria, implementation and evaluation. Significant case study anecdotes from representative countries were presented (French motorways, Polish highways, etc.).

The third part concerned the multiagency option for delivering safe system policies, with case studies from Portugal, Europe and Africa being presented.

Conclusions

In respect to technical findings, the compendium of case studies shared by PIARC Members around the world and published as part of the current cycle of work provided a wide-range of success stories from countries at all levels of

development. The case studies demonstrate clear evidence of what can be achieved, and provides the inspiration for a scaling up in similar action worldwide.

The sessions also included a range of different approaches to safe systems implementation around the world and how challenges at the local level have been overcome. This included examples on safe system interventions, the evolution of road safety culture, analytical methods for promoting road safety, crash causation and holistic approaches to road infrastructure safety.

The key conclusions for decision makers within the industry included the following:

- It is well known that road traffic injury is a major global public health problem and that urgent action is needed.
- Rapid motorisation in low and middle-income countries (LMICs) along with the poor safety quality of road traffic systems and the lack of institutional capacity to manage outcomes contribute to the growing crisis.
- Death and serious injury from road crashes is preventable if crash energies are managed so that they do not exceed human tolerances for serious and fatal injury and this is accomplished with effective, results-focused and resourced road safety management.
- The Safe System guides the planning, design, management, operation and use of the road traffic system so as to provide safety in spite of human fallibility. It places a shared accountability across all elements of the system.
- Preventing road trauma on public roads and in the course of work is a core responsibility for government, its agencies and employers and requires shared responsibility and leadership.
- A lack of accurate data has a serious impact on the effective management and delivery of positive road safety outcomes. The issue of under-reporting in many countries needs to be addressed. Guidance is available on how to improve this accuracy.
- Key safety data includes exposure data (traffic volume, population data), final outcome data (deaths and injuries), and intermediate outcome data (average speeds, protective equipment fitment and use, level of drinking and driving, network and vehicle safety quality).
- Other data is also important for assessing and addressing road risk. There is an increasing awareness of the importance of road asset data (information on safety related road and roadside design elements and features). Where high quality crash data does not exist, this information can be used to identify and treat high risk locations.
- Countries with the safest road networks have demonstrated political will by targeting better road safety outcomes, adopting and funding a systematic, evidence-based approach to intervention, and ensuring key organisational arrangements are in place.
- Intervention to improve speed management, the intrinsic safety of vehicles, the road environment, and the efficiency of the emergency medical system, all have a major role to play in addressing this new Safe System focus.
- An effective road safety management system covers three linked elements: institutional management functions, interventions and results.

Each element is periodically reviewed against successful international practice to address challenging and ambitious road safety goals.

- To produce rapid results, road safety programmes and projects must initially target high concentrations of crash deaths and serious injuries on sections and areas of the road network where the biggest gains can be made.
- Proactive approaches should also be adopted – especially for major road corridors – including impact assessment, road safety audit, safety inspection, and road assessment programmes.
- Improvements to infrastructure can contribute substantially to reductions in death and serious injury. Many high severity crash types can be eliminated with the effective use of infrastructure. This includes crashes that are thought to be caused by human error and non-compliance.

The overarching conclusions for PIARC and other international organisations included:

- The following reports were prepared during the work cycle, and it is encouraged that PIARC members distribute and communicate the associated content throughout their local industries:
 - Update of PIARC Road Safety Manual
<https://roadsafety.piarc.org/en> (PIARC, 2019)
 - National Safe System policies and implementation: A summary of international road authority practice (PIARC, 2019)
 - Compendium of Road Safety Case Studies (PIARC, 2019)

TC C-2 Design & Operations of Safer Road Infrastructure

Background Context

Safe design and operation of road infrastructure covers a very broad scope. Therefore, in order to get results delivered within the work cycle, the PIARC Strategic Plan 2016-2019 put forward 5 specific issues, and a technical committee 'Design and Operation of Safer Road Infrastructure' was formed in order to look into these issues and deliver possible technical contents and materials that would enhance the PIARC Road Safety Manual (RSM).

The work undertaken within this group will ultimately be incorporated into the next update to the Road Safety Manual, along with a new set of Road Safety Audit Guidelines which will specifically take into account the conditions in low- and middle-income countries.

Topics

The session focused on the issues pertinent to vulnerable road users, driver distraction and fatigue, and the quantum of human factors that should be considered in the road design and operations assessment process.

Conclusions

The technical findings from the range of presentations included:

- Improvements in safety can be based on the 3E's initiative *Engineering, Enforcement and Education*. Good examples of such initiatives were

identified and are providing safe and comfortable infrastructure for all road users, but in particular for Vulnerable Road Users (VRU's).

- The challenges of motorcycle safety include the following:
 - Preparing motor bikers for safe driving.
 - Minimizing high accident rate.
 - Fighting risk driving.
 - Adopting mitigating measures.
- Data was presented supporting the notion that the lion's share of seriously injured cyclists and pedestrians are single accidents due to the conditions of the road surface. It was therefore concluded that more effort has to be applied in constructing, maintaining and operating our road surfaces.
- A safe road design should be as intuitive as your smartphone and that road design now has to be self-explaining and unmistakable.
- The time of Instruction Manuals is now over. If you need signing to explain how to drive appropriately, then the road design is not user-friendly.
- Road designs with user friendly reaction times typically include the following:
 - An advanced warning section (preparation).
 - An anticipation section (identification).
 - A response section (detection/ decision).
 - A manoeuvre section (stop/ slow down).
- A catalogue of case studies, including 68 cases from 21 countries, was reported and represents an important step toward the dissemination and sharing of knowledge and best practices. However, it is important to note that the safety solutions presented are not intended to be considered as "*Best Practices*". They are simply examples of how a safety problem has been tackled somewhere else in the world.

The key conclusions for decision makers within the industry included the following:

- It is clear that there are numerous efforts and projects around the world dealing with road safety. Examples from Mexico, Malaysia, South Africa, Spain, Italy, Sweden and Algeria revealed significant positive progress concerning road safety.
- RSAs must be introduced in a mandatory way, which will necessitate the commitment of authorities.

The overarching conclusions for PIARC and other international organisations included:

- The most important message from this session was that the "*Road Safety Community*" is not at ease or satisfied with the ongoing increase in the total number of fatalities and cases of severe injury worldwide due to road traffic accidents. It must be stated that we collectively have to take further and more powerful actions, all around the world, in terms of each of the following:
 - Road safety management.

- Design and maintenance of the road infrastructure.
- Vehicle safety.
- Human factors.
- Road user behavior.
- Road safety training.
- Road safety audits.

TF C.1 Infrastructure Security

Background Context

The recent global trend in the use of ‘vehicles as a weapon’ in the conduct of terror attacks, presents a significant challenge to urban planners, architects, engineers, and building owners. The often-conflicting functional requirements of ‘protection’, ‘accessibility’, and ‘aesthetics’ mean that the provision of safe urban streetscapes and effective building perimeter security require careful design.

However despite the occurrence of incidents taking advantage of the layout and design of road infrastructure to target areas used by pedestrians in order to cause harm, some Road Administrations are still reluctant to take responsibility for embedding security as business-as-usual in the way that they design, construct, operate and maintain their infrastructure.

Topics

The session was focused on two central topics:

- Road security.
- Road resilience.

10.2.4 Infrastructure

TC D.1 Asset Management

Background Context

Asset management is a well-established discipline with relevance for all types of road infrastructure and other physical assets that is successfully implemented in many countries.

In 2012 the World Road Association decided to develop the PIARC Asset Management Manual (<https://road-asset.piarc.org/en>) to assist countries, whatever their stage of development, in maintaining their infrastructures and implementing strategies to manage their road assets. Under the editorial responsibility of the Technical Committee "Asset Management" the first edition was published in form of an online manual in 2017.

Topics

The session was focused on three central topics:

- The Road Asset Management manual.
- Dissemination and education.
- Innovative approaches to asset management.

In addition, experts from outside the Technical Committee enriched and broadened the views and work of the Technical Committee with four presentations of best practices in Road Asset Management covering:

- Economic growth through effective rural road asset management.
- Smart infrastructure asset management system on Metropolitan expressways.
- Assessment of social effects in asset management.
- Development of a method to evaluate the priorities of intervention on the road network.

Conclusions

The technical findings from the range of presentations included:

- Dissemination of knowledge and education are crucial in order to benefit from road asset management. The World Road Association PIARC has recognised this by the creation of the Asset Management Manual.
- The Road Asset Management manual focuses on operational practice, includes many case studies relating to different asset management subjects on different levels of maturity, facilitates the transfer of innovations and provides a vehicle for sharing good practices between the different administrations around the world. Furthermore, the manual includes general concepts and requirements for different asset management training courses.
- The committee identified training requirements, developed sample presentations and outlined existing asset management courses offered around the world to support the Asset Management Manual in order to advance state-of-practice and knowledge of those required to manage road infrastructure assets.
- In addition, this educational material was integrated in the Asset Management Manual.
- The session explored the general concept and requirements for asset management training courses developed during the current four-year cycle. The training aims to spread the asset management approach as widely as possible in order to get the broadest possible benefit from this new discipline, taking into account the degree of maturity of the road organisation.
- A comprehensive survey of road organisations, focusing on procedures/policies and management systems identified innovative approaches across a range of topics – inventory, road asset management and risk management, condition assessment and deterioration modelling, maintenance, improvement and communications. Some of the key innovations identified included:
 - Acquisition/processing of inventory and inspection data with increasingly sophisticated data and image capture, involvement of infrastructure users (e.g. via smartphones) and interlinking data.
 - The inclusion of key performance indicators (KPIs) and the requirements of a range of stakeholders as well as

risk/vulnerability methodologies in decision making for maintenance and improvement interventions.

- In road improvement, innovative approaches were found in noise protection and mitigating measures. Instalment of barriers is the most common solution, but noise-reducing pavements have been trialled more recently.
- The development of mass media and social networks has greatly facilitated the communication between road authorities and stakeholders. As a result, the flow of information has improved in both directions.
- Strategic asset management can achieve economic and social benefits for local communities as a result of improved performance. Specifically, the management of low traffic rural road networks under the responsibility of local road authorities can foster self-reliance in road agencies and encourage greater accountability to road users and other stakeholders.
- Smart asset management systems for road infrastructure are now currently in operation and are enhancing efficiency and effectiveness in maintenance and management of road infrastructure. This is being achieved by adopting various technologies, such as Information and Communications Technology (ICT), Artificial Intelligence (AI), Internet of Things (IoT), Robotic Technology, Mobile Mapping System (MMS) and Geographical Information System (GIS).
- Social aspects in the form of social impacts and benefits are becoming more important in the context of assessing different maintenance strategies for road infrastructure networks. There are currently projects that are defining a common basis for the assessment of social effects in the context of asset management, taking into account maintenance aspects such as traffic availability, disturbance and efficiency (travel time, vehicle operating costs, etc.), road safety (fatal and severe accidents related to asset condition), environment (noise, air pollution, natural resources, etc.) and socio economy (asset value, wider social effects, etc.).
- There is an increasing gap between maintenance needs and resource constrained maintenance operations.

The key conclusions for decision makers within the industry included the following:

- Road agencies should be supported to identify weak areas in the management of their road network and to address those areas using the available resources or alternative financing options to support maintenance.
- Advanced and innovative tools to plan an effective and efficient maintenance programme are needed to meet legal requirements.
- The identification of the vulnerabilities affecting road infrastructure is alone insufficient. It is now essential to attribute a risk level and plan a priority order of maintenance interventions.
- We must be striving for the development of management systems capable of providing quick, comprehensive and low-cost information on the road infrastructure networks which enables appropriate planning of rational and objective programmes of maintenance interventions.

The overarching conclusions for PIARC and other international organisations included:

- It was acknowledged that more focus is required on the dissemination and education of information and that specifically, a further compilation of educational training should be progressed.

TC D.2 Pavements

Background Context

On the theme of “sustainable paving solutions and sustainable pavement materials”, a range of policies and strategies from around the world were surveyed. The efforts associated with overcoming the relevant obstacles for implementing the policies and strategies were considered and a set of recommendations were provided.

Topics

This session highlighted three core themes, including:

- Sustainable paving and pavement materials.
- Low cost pavement systems.
- Non-destructive pavement monitoring and testing techniques.

Conclusions

The technical findings from the range of presentations included:

- Various techniques for low cost pavements have now been studied and the associated advantages/limitations of each are well documented.
- There is now also results for new and innovative techniques for road condition monitoring including high speed deflectometer and 360-degree image analysis technologies.

The overarching conclusions for PIARC and other international organisations included:

- Particular attention should be paid to the dissemination of knowledge and information on improving pavements and sharing data, best practice and recommendations.

TC D.3 Bridges

Background Context

The tragic collapse of Genoa’s Morandi Bridge is a stark reminder of the risks of time-related deterioration and increased loading. Modern bridges are typically designed for a life of 100 years, though many centenarian bridges still provide sterling service. Considering the number of bridges built in Europe during the expansion of the motorway networks from the late-1950s onwards, we should expect, and be prepared for, many to exceed their planned lifespan in coming decades. Facilitating this is ambitious but necessary and will be made possible thanks only to regular inspection and maintenance that ensures that building materials have not degraded, and that structural elements are fit to bear the traffic and environmental loads they face.

Topics

The session had three core themes, including:

- Bridge design toward improved inspection and maintenance.
- Technical and economic considerations of bridge rehabilitation methods.
- Inspections and damage assessment techniques.

Conclusions

The technical findings from the range of presentations included:

- All elements of a bridge should be designed such that the bridge owner is able to easily inspect and maintain them, as well as to take into account all elements that will need to be replaced during the design life of the bridge.
- Several best practices toward improved future inspections, maintenance and replacement of bridge elements with respect to conceptual design, detailed design and safe access were presented.
- For each bridge, it is necessary to determine the best rehabilitation solution taking into account both technical and economic aspects. The comparison and selection of rehabilitation methods should in essence depend on the importance level of the project.
- A more developed and rigorous process should be based on a life cycle cost analysis including both cost and benefit analyses. The comparison procedure proposed is a first pass proposal that should be tested and improved moving into the future.
- Most countries perform specialized assessments to ascertain material properties by combining destructive with non-destructive techniques. Immediate actions to exceptional events are generally based on engineering judgement, how well the responsible person/s can assess the effects of damage on performance of the structure and the safety of its users. In this decision process it is necessary to consider several influencing factors including resources, education and experience, data, and risk.

The key conclusions for decision makers within the industry included the following:

- The scope of bridge design must be changed in order to improve inspection and maintenance capabilities over the design life of the assets. This should progress irrespective of the potential to increase the initial capital cost of the bridge, under the acknowledgement that it will produce savings in ongoing future inspection and maintenance costs.
- This above life cycle cost process should be mandatory for high importance projects. However, there is more flexibility for medium importance projects to consider only the costs at present time (works, users).
- This process is recommended to be introduced as part of a global bridge stock rehabilitation process, including “prioritization of all needs” and “rehabilitation needs determination”.
- Bridge inspectors must have a defined set of knowledge and associated training. New or less experienced engineers should be included in the decision-making process for their education.

- Any compromise to safety brought about by any actions associated with a bridge issue should be well understood and qualified. The timeliness of identifying a solution and implementing the associated repairs are important before special assessments and inspections are initiated.

The overarching conclusions for PIARC and other international organisations included:

- The techniques and technologies for inspection provide inspectors with lots of information. It is important to investigate how to apply such new techniques/technologies for inspection in order to evaluate the bridge conditions.
- Rehabilitation methods should be selected in consideration of reliability, availability, maintainability and safety criteria. The financial aspect and environmental sustainability are additional aspects that should also be considered.
- Despite modern inspection methods and approaches, there are still bridge collapse disasters. It is required to investigate the current approaches to forensic engineering in order to improve the safety of bridges.

TC D.4 Rural Roads & Earthworks

Background Context

The objective of the Committee in the field of Rural Roads and Earthworks was to investigate the response of road administrations to adverse conditions as a result of climate change activities, considering the use of local, marginal and secondary materials on rural and unpaved roads.

Over the past four years the challenge was to develop outcomes on new findings that would be in line with the objectives of our tasks. In essence, to report on best practices regarding the strategies that will be adopted before and after climate change, as well as a focus on rural roads (paved and unpaved) with various technical aspects on earthworks.

Topics

The session highlighted three core themes, including:

- Exposure of roads to climate change.
- Local materials, practices and techniques.
- Management of earthworks.

Conclusions

The technical findings from the range of presentations included:

- Successful results achieved in the trial of replacing cement with wastepaper fly ash in a stabilised soil layer within pavement subgrades, with greater life expectancy anticipated.
- Many case studies now supplying credible results in respect to the use of marginal materials. A concept that has been explored for some time now, but which is now ramping up significantly.
- The technique of materials treated with blast furnace slag as a "hydraulic binder" has existed in some countries for several decades.

- Blast furnace slag, combined with sulfocalcic activation, has made it possible in several European and African countries to use good quantities of materials and local sands in regions with historically poor quality aggregates. This process provides significant economic and environmental benefits.
- Much work is being completed on new approaches to enhance the maintenance of rural roads and the general accessibility to rural areas. Comparatively, these approaches have a stronger results focus, especially in respect to access to health centres and markets, and will ultimately be targeted around building the capacity of regional areas and strengthening community administrations.
- Specifically, initiatives such as the National Road Infrastructure and Rural Transportation Strategy aims to reach the capillarity of the basic mobility support of the national population by supporting public intervention under the notion of agreement and collaboration between stakeholders and resources.
- The co-responsibility of the stakeholders involved in the solutions, which arises from consensual decisions and commitments, seeks to overcome the traditional dependent subordination that generates the inter-jurisdictional and interactoral transfer of economic resources from the levels of greater capacity and concentration.

The key conclusions for decision makers within the industry included the following:

- In general, we can say that most of these problems are recurring around the world and it is important to implement technological advances in order to minimize these problems and impacts.
- Road infrastructure is an essential public good in most countries. Asset and earthwork materials management methods must evolve to meet the demands and constraints of the 21st century.
- In light of sustainability and resilience challenges in the context of adaptation to climate change, the quality of asset management is more crucial now than ever.
- Specific earthworks asset management must be considered within general road asset management.
- Government organisations must better manage all of the individual processes involved, including the optimization of projects which will generate significant resource savings.

The overarching conclusions for PIARC and other international organisations included:

- Much work and new studies is still required to be performed on material behavior, in particular prolonged case studies in order to assess the medium and long-term behavior of road earthworks made up with marginal materials. This is a critical factor in achieving the high levels of confidence required for authorities to make the switch.
- We consider that the issues addressed in this cycle are relevant and of special attention in the incoming committees, as climate change will prevail, and these must be addressed. We need to look at the use of

practices and techniques appropriate to the situation and conditions, as well as the use of local materials or others for soil stabilization.

TC D.5 Road Tunnels Operations

Background Context

Since 1957, the date of creation by PIARC of the "Committee on Road Tunnels", the Association has conducted ongoing activities on all matters relating to the operation of road tunnels, including geometry, equipment and maintenance, operating, safety and range of environmental considerations.

The successful past work of the Association in this area was built upon with a focus on how sustainable road tunnel operations can be ensured, the development of an improved understanding of safety management in the light of accidents and fires, and expanded study of underground road networks.

Topics

The session kicked off with a summary of the Committee's outputs during the 2016-2019 work cycle and then moved to a more detailed analysis with a review of the five technical reports produced within the cycle, which included:

- An introduction to the RAMS concept for road tunnel operations.
- Prevention and mitigation of tunnel-related collisions.
- General principles for improving accessibility for persons with reduced mobility in road tunnels.
- Vehicle emissions and air demand for ventilation.
- Large underground and interconnected infrastructures: Report Part B – Specific analysis and recommendations.

Conclusions

The technical findings and noted developments from across the range of sessions included:

- Five technical reports were produced throughout the four-year cycle, in addition to a range of "technology watch" documents with the aim of observing, tracking, filtering out and assessing potential technologies from a wide field.
- The "Road Tunnels Manual" was upgraded and officially presented. The contents of this enhanced tool have been considerably enriched with new topics, figures and over 300 hyperlinks to PIARC Technical Reports on road tunnel operations and various tunnel-related regulations. The new version is currently available in English and Spanish, with other language versions to follow as soon as possible.
- The "Dangerous goods quantitative risk assessment model" was also upgraded, and a special issue of "Routes Roads" was prepared, dedicated to road tunnels.
- An international seminar on "Road tunnels in low- and medium-income countries" was carried out (in South Africa), in addition to PIARC's first international congress on "Road tunnel operations and safety" (in France), and another workshop in Montreal.

- Both the impact of ITS on road tunnel operations and safety and the impact of new propulsion technologies on future road tunnel safety and design were presented.

The key conclusions for decision makers within the industry included the following:

- The following areas were assessed as requiring more focus and attention moving forward:
 - Measures for increasing the resilience of tunnels.
 - Best practices in management (maintenance and traffic operation) in urban and heavy traffic tunnels.
 - The impact of new propulsion technologies on road tunnel operations and safety.
 - The impact of Intelligent Transport Systems (ITS) on road tunnel operations and safety.

The overarching conclusions for PIARC and other international organisations included:

- Particular attention should be paid to the dissemination of knowledge and information on improving road tunnels operations and sharing data, best practice and recommendations.

10.2.5 Climate Change, Environment & Disasters

TC E.1 Adaptation Strategies/Resiliency

Background Context

Climate change and the associated increased number of extreme weather events are a major global concern with regard to resilient road networks. Owners and operators are required to manage a very broad spectrum of threats in the future. These alone and in combination (in particular) have a significant impact on the availability of road networks. Therefore, owners and operators must address these key challenges to ensure a reliable operation of their road networks, mobility and supply chains. It is also clear that there are interdependencies with other modes of transport as well as cascading effects which should be considered as part of a comprehensive all-hazard approach.

Topics

PIARC has developed a climate change adaptation framework for roads, and was looking for strategies and case studies to increase the resilience of roads to climate change effects and extreme weather, where in particular the following topics are of interest:

- Data requirements, methodologies and approaches for collecting data and information relevant to climate change adaptation of road infrastructure;
- Methodologies and approaches for vulnerability and criticality assessments of road infrastructure with regards to possible impacts resulting from climate change (project and system level);
- Cost benefit analyses with regards to the adaptation of road networks to climate change and extreme weather.

In the field of adaptation of roads to climate change and related weather extremes, risk management approaches at object and network level have been developed and used. The following topics are of interest here:

- Implementation of risk management approaches at object and network level with the aim to identify, propose and prioritize the most appropriate measures and to mitigate risks associated with climate change and/or extreme weather events; as well as suggestions and conclusions from these implementations;
- Benchmarking of existing risk management approaches for the adaptation of roads to climate change and/or extreme weather.

As compared to traditional risk management, the concept of resilience is a more comprehensive and generic all-hazard approach, which starts well ahead of possible events (prepare, prevent, protect) and in particular also includes the phase after the occurrence of the event (respond, recover). Within the session frameworks, methodologies and approaches for resilience management of roads were addressed.

Conclusions

The technical findings from the range of presentations included:

- Using the Case Study Catalogue and the Case Study Matrix, which are part of the Case Study Database, relevant case studies and contents could be identified rapidly. In addition to spreadsheets, the Case Study Database stores the PDF files of the classified case studies.
- The work done during this cycle included coverage of state-of-the-art case study examples of four main areas. In accordance with the PIARC Strategic Plan, these comprised, data requirements for exposure assessment, vulnerability and criticality assessments for roads, adaptation measures and economic approaches of assessing which adaptation measures provide the most cost-effective responses. These have been presented by way of state-of-the-art case studies on adaptation strategies and resilience.
- The PIARC Framework has been subjected to an investigation of applicability for various purposes, comparison with other adaptation frameworks and compliance with ongoing adaptation work. Based on this assessment, some proposals for refinement of the Framework have been formulated.
- The Framework provides a combination of a structure of tasks for adaptation to climate change and a methodology for risk assessment. It is proposed that these two aspects are separated. The structural aspect is important because it sets out the various tasks in relation to each other. The methodology aspect is not less important but is variable and needs to be variable to suit the different existing practices of road administrations. The aspect of criticality needs to be included in the assessment of risks and decisions on adaptation measures.
- A framework with a specific focus on urban aspects was presented. The review and updating of regulations and standards are also a very important building block for owners and operators of road infrastructures in the context of life cycle management. Furthermore, possibilities for the

integration of adaptation measures into asset management were presented and discussed.

- Finally, outcomes from a study were presented that help to achieve a more effective and efficient resilience management.

The key conclusions for decision makers within the industry included the following:

- PIARC's International Climate Change Adaptation Framework is most suitable for road agencies that have enough basic knowledge for carrying out a climate impact assessment and implementing adaptation measures, that already have good communication with other stakeholders, but that have not done much adaptation work yet.
- Some simplifications and refinements in the procedure are proposed in order to satisfy different levels of analysis or scope.
- The aspects of protecting road infrastructure in urban contexts are important for the efficient functioning of society. Consequently, it is imperative to understand the particularities of adapting road infrastructure in cities.
- Furthermore, it was made clear that against the background of climate change, a review and, if necessary, research of regulations and standards will be necessary.
- A methodological approach was presented, which enables road owners and operators to assess and prioritize measures and procedures to improve the resilience of their infrastructures. This methodological approach allows the identification of measures in order to increase resilience during all phases of the resilience cycle.
- Adaptation measures as well as the associated data and background information should be fed into a comprehensive asset management for further prioritization.

The overarching conclusions for PIARC and other international organisations included:

- The existing collection of case studies should be continued and extended with regard to the issues identified for the 2020-2023 cycle. This may include consideration of the inclusion of worked examples of the methodological approaches identified. This would involve integration of best-practice case studies and data requirements and converting these into worked examples for each phase of the updated framework.
- The following working fields should be of particular interest:
 - Uniform and holistic methodological approach to climate change and other hazards resilience
 - Economic aspects of resilience management, and
 - Update of the PIARC climate change adaptation framework
- Due to the global and cross-sectoral significance of climate change, PIARC should cooperate closely with relevant national, supranational and international organisations. Possible partners would include the UN (UNCTAD), G20/T20, TRB.

TC E.2 Environment Considerations in Road Projects and Operations

Background Context

Roads can have both positive and negative influences on people and the environment. On the positive side roads provide the opportunity of mobility and transport for people and goods. On the negative side roads occupy land resources and form barriers to animals. They can also cause adverse impacts on natural water resources and discharge areas.

The three most damaging effects of road construction and management are noise, dust and vibrations. Poor air quality and noise from road transport is responsible for the loss of around 3 million disability adjusted life years in Europe alone (the standardized measure of healthy years of life lost to illness, disability or early death).

Topics

The session was focused on the presentation of examples of policies and measures that represent best practice around the world to improve the health of local communities; strengthen land use and transport planning and monitor environmental indicators of performance. It specifically highlighted the latest health and economic impacts of vehicle emissions.

Conclusions

The technical findings from the range of presentations included:

- In a rapidly evolving technical domain, there is increasing pressure to provide more real-time data to communities which can be utilised to inform network management as much as informing communities as to their own contribution to traffic emissions.
- A number of papers highlighted the need to find an appropriate balance between timely responses and providing information that is reliable to inform road agencies understanding of appropriate mitigation measures which will provide certainty to protecting health outcomes within our communities.
- A new database of traffic noise policies and criteria in practice around the world that has been developed as a tool for road agencies. This represents the most comprehensive listing of policies and criteria currently used by road agencies and is available from <https://www.piarc.org/en/knowledge-base/Environment-Sustainability/Act-on-Road-Traffic-Noise/>.
- This database will continue to be updated and maintained by subsequent committees and members can add additional information by contacting noise@piarc.org.
- A range of new industry innovation, including:
 - A comparison of air quality monitoring equipment from high-cost to low cost sensors listing advantages and disadvantages.
 - The role of ITS and electric vehicles in managing air quality and traffic noise.
 - Monitoring requirements for public health implications of air quality in road tunnels.

- A comparison of the major traffic noise models utilised throughout the world.
- A review of the impacts of traffic noise on wildlife.
- A critical review of mitigation measures for both air quality and traffic noise from both a practical perspective, as well as highlighting the technical limitations.

The key conclusions for decision makers within the industry included the following:

- The best practice guides provide an overview of the range of mitigation measures available to road agencies. However, technological solutions must be supported by the following:
 - Partnerships – inside and outside of a road agency, with the right stakeholders at the right time to collaborate on new technologies and to affect an improved understanding of the importance of mitigation for both noise and air quality.
 - Systems thinking – to emphasise the need for holistic solutions and to understand the complex interactions between transport and the environment to enable effective interventions.
 - Economic Evaluation – it is often difficult to fully cost the impact of transport externalities such as traffic noise and air quality, especially at a project level. Benefits are often assessed as incidental relative to the value of travel time and costs do not fully reflect the indirect impact on the community. There is a need to better understand the full economic value associated with transport-related environmental interventions and incorporate these into cost benefit assessments. To do so, requires road agencies to undertake a systematic assessment of the air quality and noise exposure across the network and to recognise that short term profits need to be balanced against long term benefits particularly as retro-fitting mitigation is often far more expensive than avoidance or early mitigation
 - Capability development – raising capability within road agencies is an important step in ensuring that designers, planners, engineers and environmental staff fully appreciate the implications associated with network design, maintenance and development.
- In relation to traffic noise, whilst there is a need for further collaboration across planning, transport and environmental agencies on traffic noise, it is equally important that road agencies continue to share their understanding and knowledge.

The overarching conclusions for PIARC and other international organisations included:

- The need to continue to:
 - Evaluate evidence linking the emission of particles from vehicles, in particular ultrafine particles, with observed health impacts.
 - Examine validation data for low cost sensors, especially related to roadside monitoring.

- Document the linkages between air quality and climate change (summarising policies that can benefit both environmental issues as well as those that can benefit one issue but have an antagonistic effect on the other).
- In addition, there is a strong need for a more integrated approach to assessing the social and environmental impacts of air pollution. It is highly recommended that the PIARC taskforce (consisting of various disciplines) review the current economic approach to air quality impacts and recommend changes that would assist road agencies when seeking to justify investment in air pollution mitigation. Currently, it is difficult to distinguish cause and effect in the vicinity of road corridors as opposed to the benefits to the broader community.
- There is also significant fragmentation in the current efforts to address air pollution within countries and across regions. An opportunity exists for PIARC to provide a leadership role in co-ordinating the key areas of research in order to enable a more consistent, cohesive and collaborative approach among road agencies, and to avoid funds being spent in areas where research has already established limited benefits.
- Such co-ordination of effort would also support greater capacity building and dissemination of information, in particular with lower income countries where air pollution is generally the highest.
- The road noise database (RoadNoise dB) remains a key tool in highlighting the current range of policies, metrics and criteria used in the assessment and evaluation of noise. Continuation of this database will assist PIARC members in developing a consistent evaluation framework.

TC E.3 Disaster Management

Background Context

Countries that experience disasters acquire unique disaster management knowledge and develop tailored countermeasure technologies based on their experiences. As societies diversify, damage caused by disasters changes as society changes. Therefore, the type of technology necessary to manage disasters in each country needs to continually adapt as populations grow and society changes.

The most current disaster management technologies have been developed to respond to the emergency management phase. Previous disaster management technology had been mainly developed in the area of hard management, such as safe infrastructure.

A greater number of countries are currently considering the management of disasters with a series of continuously applied management techniques through the pre-event, emergency, and post-event phases. This has identified the benefits of combining hard and soft management techniques to improve overall disaster management outcomes.

Topics

The first half of the session focused on the following three core themes:

- Disaster information management for road administrators.
- Disaster management and recovery techniques for road administrators.

- The on-line risk and disaster management manual.

The second half of the session focused on following three core themes:

- Improvement of disaster management based on experiences of recent major disasters.
- Role of social networks in disaster response management.
- Road infrastructure resilience.

Conclusions

The technical findings from the range of presentations included:

- Information sharing of cooperation and communication in disaster management experiences and the associated case studies are the most important factor in improving disaster management technologies.
- The Risk and Disaster Management Manual developed during the 2016-2019 cycle is a good platform for information exchange throughout the world.

The key conclusions for decision makers within the industry included the following:

- Disaster information management is the primary and fundamental basis of emergency management. The most important considerations in disaster information management are to define how to engage with internal and external stakeholders, and to understand their information needs and expectations. A proactive approach in disaster information management will receive a positive response from road users.
- Disaster management strategy with the public is becoming important in social disaster management. This important action is now expanding into the road disaster management field as one of the potential strategies to reduce the impact of disasters.
- Resilient road transportation systems are supported not only by road administrators but also by various kinds of road related organisations. Coordination and cooperation between such organisations are very important in disaster emergency situations. Enhancing the mutual communication for daily and non-daily operation and preparing mutual action rules for non-daily operation are the first step for excellent disaster management.
- Good communication with road users during disaster emergencies is the critical issue for receiving positive reaction from the road users. Big Data and Social Networks are the potential resources for monitoring and measuring the disaster situations. Social Networks is also a potential tool for public relations in disaster management. Further research is urgent on the disaster information management technology using Big Data and Social Networks.
- Effective disaster management to reduce the impact on society is a top priority. Pre-event disaster management measures are becoming more important from a financial resilience perspective. The investment in infrastructure is beneficial in both daily and non-daily situations.

The overarching conclusions for PIARC and other international organisations included:

- Both developed and developing countries continue to suffer from the severe impacts of disasters on their respective transportation systems. International disaster information management cooperation across national and language boundaries is an outstanding issue in current disaster management.
- It is recommended that the International Road Organisations such as PIARC, IRF, REAAA and DIRCAIBEA pursue closer collaboration to disseminate information on disasters and risk management and share experiences and Best Management Practices (BMP's).
- Closer collaboration between road organisations and national governments should be also encouraged.

11. Closing Session

The closing ceremony was launched with a powerful live performance from the Abu Dhabi Police Brass Band, a troupe of over thirty musicians led by the haunting sounds of the bag pipes. This was then proceeded by a video montage of key highlights and snapshots taken throughout the five days of congress proceedings, with overlying vocals by Claude Van Rooten, President of PIARC, reiterating his sentiments on the success of the congress and giving thanks to all of the organisers.

The head of the Congress organising committee, Jonathan James, then delivered an all-encompassing wrap up of the Congress, honing in on the salient points which marked its legacy, including:

- The presence and contribution from 42 transport ministers, more than 5,000 attendees from 144 countries, 7 key note speakers, more than 500 paper presenters and over 100 formal speaking platforms and senior bi-lateral meetings
- A large range of technical sessions delivering the research of the last four years of groups of approximately 30 committee members including a pivotal first time focus on gender impacts on transport and disability inclusivity
- Profound technical advances in the areas of designing new assets, operating and maintaining assets, preserving and repairing old assets, pavement materials development, asset management and data capture
- Strategic direction updates from a range of working groups showing the importance of transparency, verification, stakeholder engagement and communication and delving deep into 5 special project sessions showcasing exemplary practice, key learnings and potential pitfalls
- Faced up to global obligations of sustainability, anti-corruption and health & safety and exploring what we are doing well and what we still need to work on
- Poster presentations on the acknowledgment and warnings on the threats and risks of data saturation, governance, funding, finance and climate change and pavilions from 26 countries forming a global community of ideas exchanged and business deals done
- A vibrant exhibition stage with cultural performances, product reveals, independent thought, marketing and corporate spotlights
- 850 people participated in a range of technical site visits
- More than 1500 downloads from the Congress App

With his final words affirming that we had all met our professional obligation to make the most of what is the oldest, the largest and the best gathering for roads and road transport in the world, and ultimately, Connected Cultures and Enabled Economies.

The Technical Director of the World Road Association, Miguel Caso Flórez, then presented the awards for best speaker and best session from the Congress proceedings that were selected by all of the delegates of the Congress from 700 evaluations via the official app.

The best speaker award was won by Anne-Séverine Poupeleer (Belgium).

The best session award was won by the Disability-Inclusive Road Transport Session, chaired by Charlotte McClain-Nhlapo.

The PIARC Secretariat General, Patrick Malléjacq, then presented the key technical conclusions from the Congress, and in essence, what was achieved. He premised his remarks on the basis that Roads need to find their place in a larger context of diversity and change, which ultimately requires a holistic approach and a global dialogue between authorities, regulators, citizens, service providers, industry and stakeholders.

He declared it was the mission of PIARC to structure and share knowledge in ways that more readable, accessible and importantly, implementable, and showcased that the mission had been taken on by over 1200 experts, structured into committees and task forces, and presented here to the broader community on the work completed over the last four years, via reports, presentations and engagement.

He formally thanked the key note speakers, moderators, speakers, the executive committee and president for their vision and leadership, ESL the Congress organising company, the interpreters and quite notably, the dedicated colleagues of the General Secretariat. He thanked everyone for their trust and support.

The PIARC Deputy Secretariat General, Robin Sebille, then joined the stage to introduce the two next major events that will mark new highlights for the next cycle of committee work. Firstly, the XVIth International Winter Road Congress in Calgary, Canada, 08-11 February 2022. And secondly, and most poignantly, the XXVIIth World Road Congress in Prague, Czech Republic, 02 – 06 October 2023.

The PIARC President, Claude Van Rooten, then held the stage to outline his closing remarks of the Congress. He thanked everyone associated with the industry, both in attendance at the Congress, as well as those not in attendance but who quietly, diligently and effectively push the industry towards its objectives. He honed in on the need for continuity between the different work cycles, but also stressed that the path can, and probably will, change, due to many new points outlined in the strategic plan. A plan which he summarised by three key words: Quality, Flexibility and Outreach.

The final closing address was then delivered by H.E. Dr. Abdullah Belhaif Al Nuami, Minister of Infrastructure Development and Chairman of the Federal Transport Authority – Land & Maritime, who stressed three key points.

Firstly, he touched on the degree of responsibility felt by the United Arab Emirates in being awarded such an important event and a show case for the theme Connected Cultures Enabling Economies, and that this had intend help shape the city. He encouraged Prague, the next host city to use the event to use the event to create similar growth and change.

Secondly, he noted the high degree of international participation, with over 140 countries represented, and that Abu Dhabi was honoured to host the wide spectrum of delegates from so many diverse backgrounds. He wished that everyone had enjoyed his prized city and that ultimately people will come back on day for another visit.

And finally, he personally thanked the significant number of ministers and international dignitaries present throughout the event, who had made a point of reaching out to him via introductions, conversations and meetings.

His final words wished that the event was a success for PIARC, for the organising committee and for the entire road sector and community.

*It has not been possible to include conclusions from all sessions in this report.
They will be available from PIARC.*

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