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MULTIMODAL SOLUTIONS FOR OPTIMIZING ROAD NETWORKS IN URBAN AND PERI-URBAN AREAS

PIARC BRIEFING NOTE

TECHNICAL COMMITTEE 2.1 *MOBILITY IN URBAN AREAS*

STATEMENTS

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

The study that is the subject of this report was defined in the PIARC Strategic Plan 2020– 2023 and approved by the Council of the World Road Association, whose members are representatives of the member national governments. The members of the Technical Committee responsible for this report were nominated by the member national governments for their special competences.

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

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EXECUTIVE SUMMARY

2023R50EN

MULTIMODAL SOLUTIONS FOR OPTIMIZING ROAD NETWORKS IN URBAN AND PERI-URBAN AREAS

A PIARC BRIEFING NOTE

The Briefing Note is part of a set of six publications of the “TECHNICAL COMMITTEE 2.1 – MOBILITY IN URBAN AREAS” expected for the 2020-2023 cycle.

Mobility in urban areas faces complex problems which need to be managed within spatial and budgetary constraints. It is therefore necessary to optimize the use of road networks through better integration with other forms of transport (rail, active modes, etc.). Multimodality giving rise to the concept of "multimodality".

Working Group 2 “Integrated transportation systems, multimodality” has collated and researched a number of case studies and examples of good practice of multimodality in several cities and peri-urban areas around the world.

So, the briefing note focuses on the strategic and future directions of urban mobility rather than technical aspects.

Integrated multimodal transportation systems are large in scale and high in complexity. Their effective, coordinated planning and management is a major challenge that affects urban and peri-urban development all over the world.

The acceleration of urbanization and urban expansion, the response to climate change, the impact of the COVID-19 pandemic on transportation patterns, and the rapid application of new technologies and new models in the urban environment have also brought new opportunities and challenges for urban transportation development, creating the need to promote multimodality in peri-urban areas.

Three main recommendations emerged from the surveys:

1. Transfer promoting solutions

The objective must be to improve the efficiency of these modes and make them competitive with the use of a private car alone (solo driving). One of the most effective ways to achieve this would be to reallocate road space to other modes making it inefficient and unattractive to use a car alone. Increasing the attractiveness of collective/shared transport is a key issue in efforts to achieve a more optimised transport systems (patronage, coverage, easily accessible, safe and clean). Rising active mobility for urban trips less than 10km long (cohesion, directness, safety, comfort, attractiveness). Improve shared mobility (car and bike sharing, carpooling, cab service).

2. Establish multimodal transit centers

Multimodal transit centers (MTCs) are distinguished by the variety of modes of transport that they bring together in one place and are specifically designed to encourage the practice of intermodality. They are also places where related activities can be developed (shops, restaurants, services, information about the city, etc.), which contribute to a more pleasant journey, facilitate the management of waiting time, and whose attractiveness can extend beyond the transport customer base. MTCs have three main functions: transport, urban fonctionnal organisation and service. The location of MTCs is a key point, they must be accessible to as many users as possible, in a variety of mode.

3. Adequate and recurrent funding for sustainable mobility

The investments needed to maintain, rehabilitate and develop multimodal transportation infrastructures (new MTCs, mass transit, Maas, bus rapid transit, preferential measures for collective transports, etc.) require major and stable revenue sources, and are necessary for a move towards low-carbon mobility. Four main principles of financing are highlighted: universality, polluter pays, user pays and beneficiary pays.

This briefing note is based on the collection of case studies and examples of good practices of multimodal optimization of road networks in terms of efficiency, resilience and sustainability, literature reviews, and guidelines that are already operating in different countries. It contains conclusions and recommendations for promoting integrated transportation systems, an in-depth briefing note based on former case studies, providing a summary for policymakers.

The work has been organised as follows. **Chapter 1** explains the background, the group's work and the methodology, while **Chapter 2** contains the general questions on multimodality as a possible opening-up to sustainable mobility, taken from the previous technical report ‘A Collection of Case Studies’. **Chapter 3** presents the general recommendations arising from the policies of the various countries and **chapter 4** takes up the specific recommendations arising from the case studies studied in the previous phase.

CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

Mobility in urban areas faces complex problems which need to be managed within spatial and budgetary constraints. It is therefore necessary to optimize road networks through better integration with other forms of transport (rail, active modes, etc.), giving rise to the concept and practice of "multimodality".

Integrated multimodal transportation systems are large in scale and high in complexity. Their effective, coordinated planning and management is a major challenge that affects urban and peri-urban development all over the world.

1.1.1. Terms of reference

These major issues of multimodal optimization of road networks in urban and peri-urban areas are addressed by "Technical Committee 2.1 - Mobility in Urban Areas ", as planned for the 2020-2023 cycle and are consistent with the objectives of Strategic Theme 2 - Mobility.

The goal of the Strategic Theme 2 is to provide useful knowledge and some sustainable answers to all communities in the fields of people mobility and transportation of goods. It takes, into account : challenges for mobility policies mentioned above, the opportunities created by new technologies, and the increasing need for alignment between mobility policies and the broader goals of communities, in a context where those goals are changing. This external context meets with the objectives of Strategic Theme 2 - to study "Mobility" developing four Technical Committees and three Task Forces[1].

Technical Committee 2.1 "Mobility in Urban Areas" focused on the mobility needs of the people living in the commuting areas to make sure that all transportation needs in relation with the services delivered by cities will be taken into consideration. It took into account the complexity of urban areas, including issues such as : integration with land planning, multimodality, public support and new mobility modes.

Technical Committee 2.1 comprises 3 issues:

- **2.1.1 Accessibility and mobility facing land use in urban and peri-urban development**
  The goal of issue is to produce a report on “Data collection and analysis of inhabitants’ mobility daily needs and accessibility and adequate level of urban and peri-urban mobility” and analyze the use of road infrastructure in urban areas by different vehicles: private cars, public buses, taxis, urban services (cleaning, ambulance, police, fireman…), bicycles, scooters… and the role of road infrastructure in enhancing mobility policies.

[1] In the 2020-2023 cycle, Strategic Theme 2 has developed four technical committees and three task forces:
TC 2.1 Mobility in Urban Areas
TC 2.2 Accessibility and Mobility in Rural Areas
TC 2.3 Freight
TC 2.4 Road Network Operation / Intelligent Transportation Systems
TF 2.1 New Mobility and its Impact on Road infrastructure and Transport
TF 2.2 Electric Road Systems (ERS)
TF B.2 Automated Vehicles – Challenges and Opportunities for Road Operators and Authorities

- **2.1.2 Integrated transportation systems, multimodality**
  The goal of this issue is to identify examples of good practice in the optimization of road networks through better integration with other forms of transport (rail, active modes, etc.) in terms of efficiency, resilience and sustainability with a focus on multimodal transit center.
- **2.1.3 Evaluating impacts of new mobility in urban and peri-urban areas**
  The goal of this issues is to identify examples of good practice of smart cities using ICT Technology and evaluate the impacts and challenges of new mobility (automated driving, sharing, mobility as a service (MaaS)) on the urban environment and social inclusion.

1.1.2. Focus of WG2

To meet the objectives of Technical Committee 2.1 on "Mobility in Urban Areas", Working Group 2 "Integrated transportation systems, multimodality" has researched case studies and good practices on multimodality in several cities and peri-urban areas around the world.

Sustainable urban mobility is a priority for all city administrations and governments. Understanding how all modes of transport operating within the city is therefore of growing importance. Making cities less congested, cleaner and sustainable requires an understanding of how use them more efficiently rather than trying to eliminate any of the means of transport available. This means, treating all forms of transport equally, to guarantee access to citizens according to their needs. This is the starting point for developing sustainable and environmentally friendly cities. This is how multimodality emerges, which is beginning to be applied in urban transport management plans as a way of promoting more sustainable and less polluting mobility. Multimodality enables the possibility of combining several forms of public and private transport on the same route, including, private vehicle, active mobility (walking or cycling) and car-sharing platforms.

To be able to say that a city has a sustainable urban transport mobility plan and promotes multimodal mobility, it will be necessary to plan public transport logistics (transport cards, information systems, etc.), along with urban infrastructure (car parks, stations and stops, routes). The key lies in connecting infrastructure and integrating services into one. This enables for example, the scenario where someone parks their car in the car park at the train station, travels to the city center by metro, and completes their journey with a shared bicycle -all coordinated in an efficient and affordable way. The key is to connect all infrastructure and integrate all services into one ; for example, being able to make all payments (car parking, public transport and shared bicycle fare) with a single payment card. Coordinating the times and schedules of the different sections of the same route is another key aspect to efficient multimodal travel

The challenge is therefore in the connection and integration of infrastructures and public services.

In 2023, PIARC published the report "Collection of Case Studies" [1] from Working Group 2 which is one of the six expected outcomes by the cycle 2020-2023.

The report "Collection of Case Studies" contains 16 case studies from 8 countries (Belgium, China, Czech Republic, France, Italy, Japan, Korea and Uganda). *The collection of case studies was conducted in two stages: the first stage was a survey of good practices aimed at collecting as many as possible worldwide, which was conducted from March to September 2021. The second stage was the development and collection of case studies. This was carried out from October 2021 till March 2022.* It's main purpose is for technicians and engineers from various countries to exchange

technical experiences and best practices in integrated transportation systems from around the world.

This briefing note, is based on the 'Collection of Case Studies', and has been developed for decision-makers rather than technical experts. It contains the conclusions and recommendations on integrated transportation systems from the previous "Collection of Case Studies" report as well as an analysis of general guidelines of the different countries collected by another survey in October 2022.

The briefing note focuses on the strategic and future directions of urban mobility rather than technical aspects. Its scope covers :

- What are integrated transportation systems and how can we effectively define them?
- Why is there a need to promote integrated transportation systems, and what benefits would be achieved and problems addressed through promoting more integrated transportation systems?
- What recommendations to help with the optimization of road networks through better integration with other forms of transport have been identified in the case studies, and how might these help improve efficiency, resilience and sustainability with multiple views (social equity, affordable cost, environmental impacts etc.)?
- What key takeaways and policy recommendations should be learned from the global best practice and delivered to PIARC members?

1.2. METHODOLOGY AND LIMITS

This briefing note is based on the literature review and the Collection of Case Studies report, as well as an analysis of the general guidelines of the different countries collected by a survey in October 2022 by Working Group 2.1.2 of TC 2.1.

The briefing note is based on feedback from 15 countries from different continents. The reach is broad and presents many common issues on multimodality.

The case studies and recommendations from the previous cycle with the report PIARC TC B.3 -Urban Mobility "Sustainable Multimodality in Urban Regions" [2], that analysed several multimodal transit centers in Spain provides further, relevant material.

When considering the outputs from this work, several biases to the work have been noted. The analysis of the case studies is not exhaustive and any specific issues or needs of South American and African countries have not been taken into account. This create a gap in the content of this briefing note as many of these countries have developed good examples of public road transport solutions and good practices with regards to multimodal transit centers. In addition, some LIMIC countries have a large "informal sector" in transport services, which is not reflected in the surveys.

The constraints imposed by the COVID-19 pandemic and the lack of face-to-face meetings created many challenges for the Working Groups. The 3 Working Groups liaised virtually between themselves as well as coordinating the work (in a virtual environment) with other TCs and Task Forces, such as T.C. 1.1 - Performance of Transport Administration, T.C. 1.2 - Planning Road Infrastructure and Transport to Economic and Social development, T.F.B.2 – Automated vehicles – challenges and opportunities for road operators and authorities, T.F. 2.1 – New mobility and its

impact on Road Infrastructure and Transport, T.C.2.4 – Road Network Operation/ITS, T.C 3.1 – Road Safety and T.F.3.1 – Road Infrastructure and Transport Security.

2. GENERAL ISSUES

This briefing note contains the general issues on multimodality as a possible opening for sustainable mobility deriving from the previous Technical Report "A Collection of Case Studies" [1].

2.1. WHAT DO WE MEAN BY "INTEGRATED TRANSPORTATION SYSTEMS AND MULTIMODALITY" IN URBAN AND PERI-URBAN AREAS?

①In terms of **location**, the scope of transportation modes studied in the WG 2.1.2 is mainly urban, taking into account peri-urban areas.

In the 2016-2019 cycle, TC B.3 put forward in its report "when we focus on transportation daily needs, we must take into consideration not only the urban area itself but also its commuting area which is at least ten times bigger than the urban areas". This definition of "urban regions"[2] has been used in this briefing note, when we refer to integrated transportation in urban and peri-urban areas.

Working group 2.1.1 aims to produce a report on "Data collection and analysis of inhabitants mobility daily needs, and accessibility, and adequate level of urban and peri-urban mobility", an issue that has a strong relationship with the work of working group 2.1.2. The data collection and analysis is important in the context of climate change, because to reduce CO_2 emissions the focus must first be on daily long trips (even if they represent only 20 or 30% of the number of car journey) as, because they represent 80% of CO_2 emissions.

Daily mobility must address both short daily trips and long trips from the suburbs, which have a high impact in terms of pollutant emissions. In view of increasing urbanization, there is a need to take into account long daily trips through multimodal solutions.

②In terms of **transportation mode**, Integrated transportation systems or multimodality has the following meanings. "Integration" includes both system integration and system optimization. "Integration" refers to the existence of two or more traffic systems or modes that can be distinguished from each other, are interconnected and interact with each other, distributed in a certain form, and under the given constraints, formed for the purpose of achieving the optimal structure. "Integration" has the following properties:

1)Integrity: As a whole with a certain structure and function that is organically combined by several interacting and interconnected parts, its essential feature is organic integrity.

2)Aggregation: An integrated system is composed of two or more traffic subsystems that can be distinguished from each other.

3)Orderliness: Also known as hierarchy, due to the different positions of the components that make up the integrated system in the whole system, different levels are formed, so that the integrated system can deliver a higher function and role, and efficiency.

4)Correlation: The elements or subsystems that constitute an integrated system are interconnected and interact with each other.

5)Environmental adaptability: Through resource integration, overall consideration is given to the external environment of the system and the characteristics of the interrelated elements in the system ; strategies are adopted to maximize the overall benefits of the system.

③In terms of **contents**, integrated transportation systems mainly include the construction and operational organization of multi-mode passenger transport hubs or transfer centers, including land use, development, multi-agent operation, investment and financing, excluding comprehensive utilization of road systems.

2.2. WHY WE NEED TO PROMOTE MULTIMODALITY IN URBAN REGIONS

Urban transport systems are complex due to their multimodal composition. For example, TC B.3 reported in the previous cycle 2016-2019: "The urban transportation consists of several elements such as travel actors and their needs, freight planners and their needs, movement itself of people and goods, transportation facilities, transportation services and their costs. They are influenced by social and economic conditions such as income levels, social customs, administration systems and safety concerns from crimes"[2].

Due to the diversity and complexity of their constituent elements, urban transportation systems face many challenges. An example is, the challenge of public transportation providing an attractive door-to-door transport service outside the city center, especially in peri-urban and rural areas. This challenge means many people continue to depend on cars for much of their travel, aggravating "urban diseases" such as traffic congestion, carbon emissions and air pollution.

The acceleration of urbanization and urban expansion, the response to climate change, the impact of the COVID-19 pandemic on transportation patterns, and the rapid application of new technologies and new models in the urban environment have also brought new opportunities and challenges for urban transportation development, creating the need to promote multimodality in peri-urban areas.

- **Accelerated urbanization and urban expansion**

More and more people have moved into cities, making urbanization a dominant global trend. It is estimated that by 2050, 66% of the world's population will live in cities[3]. In the coming decades, it is expected that 95% of the world's population growth will take place in cities (Habitat 2011; Program 2010)[5]. They will be home to an additional 2.5 billion people, bringing the total urban population to approximately 6.5 billion[3].

Much of this growth in urban population is occurring through urban sprawl, resulting in the spatial layout of some cities facing a variety of problems caused by disorderly expansion. Decrease in population density caused by urban sprawl increases the daily travel distances, which leads to car-oriented development with resultant increases in the fuel consumption and pollutant emissions. Mobility is becoming increasingly constrained (for cars) and congested (both for existing public transport and car) in metropolitan, urban, peri-urban and in some rural areas. Travel demand (passenger and freight) continues to increase, and the demand for commuting travel increases alongside the diversification of travel groups and travel needs, which creates more complex requirements for the integration of multi-modal transportation City authorities need to find ways to use scarce space more fairly and efficiently[4].

- **The needs to address climate change is more urgent**

The goal of carbon neutrality is the inevitable trend of sustainable development of human society, and transportationfaces significant challenges as it moves toward carbon neutrality (UN 2030 Agenda[6]; Glasgow Climate Pact). Faced with the ever-increasing needs and the challenges of climate change, we need a more efficient, greener and inclusive (all age and gender friendly and

accessible to all communities and people) transport system. Regional and national action may support city action, yet cities are often well placed to lead the way. City alliances can be helpful in guiding local action[7]. In terms of achieving a carbon neutral society, the need to reduce oil consumption, and the oil crises that drive up the price of oil and prevent people from travelling are important factors. Functioning, integrated shared mobility can limit the use of private vehicles and enable urban transport systems to become truly sustainable[8].

Meanwhile, hazards (hurricanes, rainstorms, floods, etc.) that are exacerbated by climate change, as well as the geopolitical energy crisis reminds us of the urgency to reduce the transportation system's reliance on fossil fuels. Achieving this will require significant behavior changes in the travel choices people make. Enabling these changes is dependent upon infrastructure (road and rail, transport hubs....) and associated services so more sustainable travel options are more resilient, robust and available to the communities and passengers they serve[9].

Resilience is not only about climate change, infrastructure and transport systems should be more resilient to any disturbing situation, predictable or not (big events, strikes, fuel prices, accidents, terrorist attack…).

- **A green recovery from the COVID-19 pandemic**

The COVID-19 pandemic has brought about many changes to travel habits. In many cities, public transport systems were on the verge of collapse in 2020, following significant declines in ridership, revenue and passenger trust. Many people returned to private vehicles as their first choice of mobility, while others, lacking access to safe and reliable transport services, were stranded by lockdowns and deprived of work to maintain their livelihoods, resulting in greater impoverishment among the most vulnerable groups[10].

The proportion of trips by independent and individual travel methods (most notably active modes including bicycles, walking and scooters) has continued to increase[11], supported by expanded pedestrian and cycling infrastructure in more than 250 cities[10]. Investment in bicycle and walking infrastructure is an important driving force for the green recovery after the pandemic and for a sustainable mobility as a whole. Active mobility can play an important role in improving the ability of the urban transportation system to respond to public health incidents (and also sudden natural disasters). Therefore, the connection between motorized modes and active modes should be explored.

In addition, we should also pay attention to the long-term reform of the transportation system, to optimize supply and demand, coordinate resources, and improve overall input-output efficiency and social and economic efficiency. Lessons learned from the COVID-19 pandemic should be used to rethink mobility and create solutions which can withstand potential future crises and support the achievement of global economic recovery. The pandemic has allowed communities to look at public space and road sharing differently. There are numerous examples from different countries of financial funding to encourage the use of alternative modes (carpooling, active modes, multimodal transit center, planning, etc...).

- **Accelerated application of new technologies and new models in the field of urban transportation**

Advances in ICT technologies means that the technical conditions for one-stop services in urban travel planning, boarding and transfer, etc. are available. One area where urban transportation is developing is in the direction of Mobility as a Service (MaaS) is defined as ”the integration of various forms of transport services into a single mobility service accessible on demand” [2]. The implementation of MaaS or a complete and coordinated multimodal information system between several operators is a major element in the evolution of the connected society, and it could lead to a better quality of service and increase attractiveness of alternative modes.

While we expect mass public transport to remain the backbone of urban mobility, new mobility services have significant potential in helping to provide flexible solutions for first and last mile. MaaS can be especially useful to help reach city outskirts and suburbs or less accessible sites, and at non-peak hours when traditional transport modes are not running. The complementarity between different modes of public transport provides travelers with safe, reliable and accessible mobility from door to door with the application of MaaS[12]. Autonomous vehicles will also have an impact on everyday travel and future infrastructure needs, while in the shorter-term improved sensor technology and computing power/software is enabling increasing levels of automation in transport across a number of modes[13]. All these technological advances feature in and enable the mobility of the future and promote alternative modes to the self-driving car through optimized services including transfer services linked with transport hubs.

Otherwise, sharing of mobility instead of ownership, facilitates the use of the different modes. In this sharing economy and sharing mobility, new business models appear, and private persons become a service provider as well.

- **Differences in travel demand in different types of countries**

Given the common challenges and opportunities mentioned above, global differences in urban transport systems are also an important consideration. Developed countries are trying to increase investment in green transportation infrastructure and build more multi-modal interchange centers to meet urban and transportation needs. Some developing countries lack the major infrastructure necessary for their development and growth. Some countries or territories do not have the financial means for investment and operation, nor the need to implement a high level of service with heavy systems everywhere for a lower ridership. More flexible and diverse solutions can be explored to adapt the transport offer to the needs of the inhabitants and the size of the community.

These constraints encourage alternative modes and their combination - rail, bus, active modes and carpooling. Compared with the efforts to improve the efficiency of one single transportation mode in the past few decades, the modern integrated transportation system pays more attention to the coordination and connection of multiple transportation modes to improve efficiency, resilience and sustainability across the system.

3. GENERAL RECOMMENDATIONS

3.1. OVERVIEW

The purpose of this chapter is to provide general recommendations for the promotion of alternative mobility to the private car and the optimization of the road network through better integration of different transport modes. Recommendations are based on a new survey carried out by WG2.1.2. The survey was conducted between September and October 2022 of 16 PIARC member countries, which are presented in the following table. It is interesting to note that the surveys come from almost every continent and are from countries with varying levels of development.

The two main questions of the survey were:

- What are the mobility challenges of your country/region and how are you addressing them?
- Describe a national (Nat.), regional (Reg.) or metropolitan (Metro.) public policy/document related to optimizing the use of the road network.

	Type of policies			**Topics addressed in policies (chapter structure)**				
Country/region	**Nat.**	**Reg.**	**Metro.**	**3.2 RTI approach**			**3.3 MTCs ****	**3.4 Funding**
				R*	**T***	**I***		
Belgium		X		X	X		X	
Czech Republic	X				X			X
China	X				X	X		
France	X			X	X	X	X	X
Germany	X	X		X	X	X	X	X
Italy			X	X	X	X	X	
Ivory Coast			X		X		X	
Japan	X				X	X	X	
New Zealand	X		X	X	X	X		
Niger	X				X			
Portugal	X				X	X		X
Quebec/Canada	X			X	X	X	X	X
South Africa	X		X		X			X
South Korea	X				X	X		
Switzerland	X				X			
USA	X				X		X	X
Total: 16	**13**	**2**	**4**	**6**	**16**	**9**	**8**	**7**

* R: Reduce - T : Transfer - I : Improve

** MTCs: multimodal transit centers

It can be seen that more than 80% of the surveys related to national policies. In general, these policies aim to shift to an era of "modern mobility" based on transportation systems that are efficient, safe, equitable, integrated with the environment, and compatible with human health and ecosystems.

> "With the recent convergence of Information and Communication Technologies (ICT) and innovative technologies in the field of transportation due to the 4th industrial revolution, the era of mobility completely different from the previous one has arrived"
>
> ** Content from the South Korea survey*

Reduce-Transfer-Improve (RTI) is a transportation planning approach that consists of three steps, which should be prioritized as follows:

> 1. **Reducing** trips or distances to be travelled to meet the various mobility needs through better integration of land use and transportation planning;
> 2. **Transferring** travel to less energy-intensive and greenhouse gas (GHG)-emitting modes, such as public and active transportation;
> 3. **Improving** the efficiency of vehicles by reducing their carbon footprint, but also improve travel in terms of cost, quality and safety.
>
> ** Content from the Quebec/Canada survey*

All the policies presented relate to at least one of the three steps. Six countries had targets related to the "reduce" step, all 16 countries to "transfer" and 9 to "improve". The three countries surveyed with the lowest levels of development (Ivory Coast, Niger and South Africa) only reported actions related to the transfer step, while in the majority of developed countries (10 out of 13), the actions were also related to at least one of the other two steps.

Since the committee's objectives are directly related to the « transfer » step, this will be the focus of the work ; « reduce » is more related to land use planning and « improve » to technological considerations.

Three main recommendations emerged from the surveys, and the structure of this chapter is based on the:

- Transfer promoting solutions; (section 3.2)
- Establish multimodal transit centers (MTCs); (section 3.3)
- Adequate and recurrent funding for sustainable mobility; (section 3.4)

The content of the sections is drawn from the surveys, more specifically from the countries indicated by an "X" in the previous table. Also, when it was deemed necessary, the content for this chapter was enhanced by some additional literature on the subject as well as by discussions between the members of the working group. The use of a literature review is supported by the desire to have recommendations that are as general as possible, which would otherwise be difficult given the somewhat limited number of countries studied. It is also important to note that just because a country does not have an "X" in a recommendation does not mean that its planning does

not include this aspect. It means that it is not addressed in its survey response. Thus, this is by no means a complete picture of the transport planning activities in the responding countries.

3.2. TRANSFER PROMOTING SOLUTIONS

Transfer promotion aims to encourage a modal shift from space intensive and high GHG emitting modes (mostly private car), to modes that are more efficient in these aspects, such as collective, active or shared modes. It is important to promote each of these modes to encourage this transfer. The objective must be to improve the efficiency of these modes and make them competitive with the use of a private car alone (solo driving). Solutions are detailed in the following subsections.

Reallocating road space

As suggested in the New Zealand survey (see box below), one of the most effective ways to achieve this would be to reallocate road space to other modes making it inefficient and unattractive to use a car alone (modification of a lane to reserve it for buses, for carpooling, removal of parking to add a bicycle path, pedestrianization, etc.).

> "Achieving significant emissions reduction through mode shift to public transport, walking and cycling quickly and affordably is a very significant challenge. Rapid progress requires the reallocation of existing road space through the introduction of bus lanes, carpool lanes and cycle lanes. Space currently used for parking and general traffic capacity is reallocated to these other uses."
>
> ** Content from the New Zealand survey*

The surveys also indicate that it is important to optimize the existing infrastructures, such as by modernizing a railway station, extending a bus station, upgrading a bicycle path or making a crosswalk safer. Maintenance is also a key element to optimise the use of the existing infrastructure.

Collective transport

> "Public transport accessibility is key to providing economic opportunities to society, together with walking and play a prominent role in sustainable urban mobility."
>
> ** Content from the South Africa survey*

> "**Program for the Densification and Reinforcement of the Public Transport Offer (PROTransP)** : it aims to promote the strengthening of current public transport services and the implementation of new, regular and flexible public transport services. That result in gains of accessibility of the territories and the access of their populations to the main services, and places of employment. In addition, that promote the transfer of current users from individual transport to collective passenger transport, contributing to a more sustainable mobility patterns and the decarbonisation of mobility."
>
> ** Content from the Portugal survey*

Increasing the attractiveness of collective/shared transport is a key issue in efforts to achieve a more optimised transport systems as it can be the cornerstone of urban mobility. Collective/shared transport is also recognized as one of society's most valuable tools for reconciling mobility needs with the challenges of sustainability.

Several countries aim to develop a high-quality collective transport system. Although the way to achieve this varies among the countries surveyed, some state-of-the-art measures are summarized below. The choice and implementation of these measures depend strongly on the context and the objectives of the authorities. Planning must balance the trade-offs involved in collective transport, such as area coverage vs. service frequency, service speed vs. number of stops and operating hours vs. frequency (Khan 2021) [14]. It is also important to keep in mind the two main goals of collective transport, which are patronage and coverage.

The goal of **patronage,** often carried by heavy modes (train, metro, tramway, etc.), is to organize the collective transport network where it will attract the most passengers, connecting where people are to where they want to go (high-demand routes).

Patronage-centric systems generally used for commuting to work or school are often the most profitable in terms of taxpayer dollars. In addition, where high population densities are achieved, this is often the best way to achieve efficient mobility which can compete with the car. Most countries surveyed had objectives related to patronage.

The goal of **coverage**, often carried by lighter modes (bus, shuttle), is to provide a basic level of service, i.e., geographic equity for as many people as possible taking into account the mobility needs of disadvantaged passenger groups. Part of its interest also lies in linking up with heavier modes (patronage). Compared to patronage-centric network, it will be a lot less competitive with the car. The goal of coverage is no less important, as services like this are truly essential for many community members who have no other means of transportation.

In summary, it is important to keep in mind those two goals, and not to rely only on patronage, although this is the most effective way to compete with the car. Whatever the objective, it is also important for collective transport to:

- **be easily accessible by multiple modes** (preferably active modes);
- **be safe, clean, comfortable and easy to use** (information, fare, ticket purchase, etc.; both physically and numerically).

An integrated tarif system is also a key factor to assure the attractiveness of public transport. For example, the evolution of digital tools makes it possible to develop personalized offers, such as information or fares adapted to different types of travelers or different uses. This personalization of the offer is also reflected in Mobility as a Service (Maas).

> "New urban transportation systems adapted to automated driving and MaaS will be realized by eliminating through traffic by means of ring road development, reallocating road space, developing mobility hubs, and converting parking spaces. "
>
> ** Content from the Japan survey*

Active mobility

Ten of the 16 surveys focused on national policies, resulting in fewer mentions of active transportation, as its planning tends to be considered more at the metropolitan or regional level. However, where it is mentioned (mostly in European countries), it is stated that there has been a significant increase in cycling and walking in recent years, especially due to the pandemic.

"42% of trips are made on foot without a real policy to improve the conditions for this mode of travel."

** Content from the Ivory Coast survey*

"The potential for walking and cycling development is significant related to short trips: 65% of all car trips have distances less than 10 km."

** Content from the Germany survey*

It is clearly established that sustained efforts must be made to promote active mobility, and that it represents an enormous potential to improve urban mobility, and more broadly the quality of life. Many urban trips are less than 10 km long, so active mobility can be the fastest, easiest, most environmentally friendly and least expensive way to get around. In addition to their effectiveness over short distances, active travel modes can lead to improvements in. For longer trips, active transportation can be used to complement collective/shared transportation.

With this awareness, several authorities are rethinking the space dedicated to cyclists and pedestrians in the urban environment to promote a modal shift. There is a general desire to expand and improve active transportation infrastructure networks to be denser, better connected and more widespread. To do this, 5 design principles from the literature[15] can be applied. Maintenance is an additional key issue.

1. **Cohesion**: connecting origins and destinations
2. **Directness**: creating short and fast routes
3. **Safety**: reducing stress and minimising exposure to pollutants and noise
4. **Comfort**: minimising stops or nuisance
5. **Attractiveness**: creating a pleasant environment

However, encouraging active transportation requires more than just building dedicated infrastructure. It is also important to implement traffic calming measures, such as speed bumps, curb extensions, priority at intersections, road markings and speed limit management. All those measures increase cyclists' comfort and sense of safety by helping to reduce the volume and speed of motorized traffic (P. Schepers et al. 2017)[16]. A good example of this is the "30 city" found in Brussels (the capital of Belgium) and elsewhere, where the speed limit is limited to 30 km/h on most of the road network.

Here are four examples of inspiring public policy related to active mobility.

Czech Republic: CYKLOVIZE 2030 for safer cycling infrastructure

The objective of this project, which started in 2021 is to build a comprehensive and safe network of bicycle paths and long-distance bicycle routes throughout the Czech Republic. The first step which is now underway is to create a unified map of the transport network for cyclists. This map will help to determine the basic network of long-distance cycling routes and to determine the transfer points between individual regions. Another task will be to divide cycle routes into sections according to their current and target state and to create financial instruments for its implementation.

Portugal: U-Bike to promote cycling at university

U-Bike Portugal was a national project that started in 2016 and ended in 2022. It aimed to promote active mobility and encourage the adoption of more sustainable mobility habits in 12 universities/ academic communities. The project aimed to demonstrate the potential of conventional and electrically assisted bicycles as an alternative to single-occupancy vehicles for daily travel. To do this, 2249 bikes were purchased (1537 electric and 712 conventional) as part of the project and were loaned to the academic community (students, teachers and staff). 1.68 million km were travelled, allowing a reduction of 288.71 tonnes of CO_2 equivalent and 80.28 tonnes of oil equivalent.

France: Bicycle plan to make the bicycle a full-fledged means of transportation for daily

Launched 4 years ago, the bicycle plan is a valuable tool for the ecological transition. It consists of 4 key measures:

1. The Active Mobility Fund: since 2018, 410 million (EU) has been invested for bicycle infrastructures in the form of calls for project. This has led to the development of 22,000 kilometers of cycling facilities
2. Mandatory marking of bicycles: visible identifier on the frame of bicycles to combat theft, one of the main obstacles to bicycle use
3. The sustainable mobility package: allows private and public employers to cover the travel expenses of their employees on their home-to-work commute by bicycle, carpooling or using other shared mobility services
4. How to ride a bike: program enabling all children entering school to learn how to ride a bike in real-world conditions

Switzerland: Cycle Route Act for better and safer cycle paths

In 2018, the Swiss population approved the federal decree on cycle paths. In doing so, they have opted for an upgrade of the cycle paths. The new federal law on cycle paths (Veloweggesetz) ensures better and safer cycle paths by obliging the cantons to plan and implement cycle path networks and the federal government to create cycle paths on its roads. At its meeting on 23rd November 2022 the Federal Council decided that the new law will enter into force on 1s January 2023. In total, two national cycle path networks are planned: one for commuter traffic and one for leisure traffic.

Shared mobility

Shared mobility describes the trend toward self-service access to transportation infrastructure and services, as well as collaborative means of travel. It can be a good alternative to the private car and can complement collective and active transportation. Since shared mobility solutions can help reduce individual car ownership and use, they have the potential to lead to a reduction in the number of people who use cars, to reduce traffic congestion and greenhouse gas emissions, among other benefits. There are five main types of shared mobility.

1. **Car and bike sharing**: shared use of a fleet of car or bike (electric or not) by multiple users on an as-needed basis.
2. **Carpooling**: when more than one person uses the same car to make a trip.
3. **Commercial carpooling**: commercial ridesharing involves using a platform to connect customers with drivers who provide transportation services for a fee

4. **Cab service**: motor vehicle driven by a driver and designed to carry passengers and their luggage from door to door for a fee
5. **Vehicle lending between people**: this is another variation of car sharing in which a vehicle owner makes his personal car available to others, who can rent it for short periods

Ideally, all these forms of shared mobility should be encouraged to provide as many options as possible and to for people to **use them instead of their own**.

Three elements emerged from the surveys to encourage shared mobility:

- **Involving employers**: With proper planning, trip between home and work, which represents a large volume of travel, can be shifted to shared mobility. Thus, it is important to help companies to put in place the tools to promote it. Dedicated parking spaces, public funding and carpooling incentives can be put in place;
- **Valuing the benefits**: The benefits of shared mobility are multiple (social, environmental and economic). Therefore, it is important to highlight these benefits by proposing ways and tools to measure them. For example, the savings in gas, car owning, GHG emissions and time could be calculated;
- **Develop a platform to connect carpoolers**: Carpool matching services help individuals find carpool partners. These services are now almost always automated and web based. They allow individuals to search for partners who use the same route as them, not just who have the same origin and destination points, for a single trip or for repeat trips.

> "A sustainable mobility package, up to 400 €/year to go to work by carpool or bicycle: employers will be able to contribute to the travel expenses of their employees through this package, exempt from taxes and social contributions."
>
> ** Content from the France survey*

3.3. ESTABLISHING MULTIMODAL TRANSIT CENTERS (MTCS)

A multimodal transit center (MTC) is a place where different transportation networks (private car, active modes, shared modes and collective transport) are interconnected. MTCs are distinguished by the variety of modes of transport that they bring together in one place and are specifically designed to encourage the practice of intermodality. In contrast, hubs that focus solely on car and public transport are usually called park-and-ride facilities and are sometimes referred to by the acronym P+R.

MTCs are not however, simply places of transit. They are also places where related activities can be developed (shops, restaurants, services, information about the city, etc.), which contribute to a more pleasant journey, facilitate the management of waiting time, and whose attractiveness can extend beyond the transport customer base. Literature[17] assigns three main functions to MTCs:

1. Transport: organise flows of passengers by offering a good connection between transport networks so that interchanges are safe and transfers reliable
2. Urban: be a driving force for the territory's growth and functional organisation
3. Service: create lively places, make space more practical and pleasant, serve both users and neighborhood residents. That means that attention should be paid to the delivery operations of these services - modes, parking facilities, dimensioning and geometry of the infrastructure -. This aspect is often neglected.

Intermodality should be treated as a comprehensive process that includes not only physical design, but also multimodal information, consistent fare and ticketing policies, and coordination of the transport offer.

> "In a network based on the interchange between different public transport systems and on the intermodality with private transport systems (cars, motorbikes, bicycles) and with pedestrian mobility, the organisation of the main nodes of interchange assumes a significant importance. This is why the new Mobility Hubs will be built in 30 railway stations and terminals, where the greatest opportunities of transhipment/intermodality are concentrated. (…) The 30 Mobility Hubs are organised to follow a "rendez vous" format, which makes them more comfortable and minimises the waiting time for exchanges between rail and road services."
>
> ** Content from the Sustainable Urban Mobility Plan of metropolitan Bologna (Italia)*

Most of the countries surveyed aim to develop or improve MTCs. Their implementation is becoming increasingly important in the context of the diversification of mobility services. MTCs can be of different scales: central station, bus or commuter train station, metro station, bus network terminal, or a simple bus stop connecting several busy lines. Based on a successful link between transportation and land use planning, MTCs can provide fluid and efficient mobility for citizens and promote higher density urban development.

In urban areas

The location of MTCs must be accessible to as many users as possible, in a variety of modes. To achieve this, those 4 aspects are drawn from the surveys:

- the **connectivity** of the site to the pedestrian, bicycle and collective transportation networks;
- the **density of activity** around the site, which allows the population to be concentrated near the hubs;
- **each network must be designed to be consistent with the other networks**, particularly in terms of territorial coverage and the possibility of intermodal connections;
- they must also be in a way that reflects the reality of **people's movement flows**.

In suburban and rural areas

MTCs can also be in sparsely populated areas (suburban and rural areas). In this context, given the greater distances to travel, it is important to ensure that MTCs are accessible by collective transportation and shared mobility. Although the points just made apply also to suburban and rural areas, it is important to offer pleasant and safe waiting areas, with services, if possible (Wi-Fi, shops, parking, lockers, indoor protection, etc.), considering that the waiting time may be higher due to possibly less frequent services.

3.4. ADEQUATE AND RECURRENT FUNDING FOR SUSTAINABLE MOBILITY

Several countries are seeking significant investments to promote multimodality alternative mobility to solo driving. The investments needed to maintain, rehabilitate and develop multimodal transportation infrastructures (new MTCs, mass transit, Maas, bus rapid transit, preferential

> "The generation of other revenues apart from the fares through Advertising on the system, Parking fees and Land-value capture should be adapted by all major municipalities."
>
> ** Content from the South Africa survey*

measures for collective transports, etc.) require major and stable revenue sources, and are necessary for a move towards low-carbon mobility.

Slightly fewer than half the countries (7 out of 16) highlighted issues related to funding. It was commonly noted that within a few years, revenues are likely to fall short of projected needs in several countries. The current model of transportation financing, based largely on gasoline taxes, vehicle registration fees, and driver's licenses, may no longer be the best suited to the electrification of transportation and a less car-based mobility.

In this context, it is therefore necessary to continue the reflection already begun on transport financing by evaluating the various economic tools available and their effects on transport revenues and demand. Four main principles of financing can guide this reflection:

1. **Universality**: All public revenues go into a general fund from which all public expenditures are financed; (income tax, consumption taxes or property tax)
2. **Polluter pays**: carbon emission fees or fees on the acquisition of a vehicle or its components;
3. **User pays**: tolls, kilometric contribution, parking chargers or taxes on energy consumption;
4. **Beneficiary pays**: Those who do not directly use a utility but benefit from its presence should partially offset the costs associated with the services based on the value of the privileges obtained; (contributions from real estate developers and companies or royalties on transported materials)

"National authorities should formulate broad guidelines on mobility planning and initiate projects based on them, and provincial and metropolitan authorities should produce plans based on those directions and participate in the operationalization of these projects."

** Content from the China survey*

4. SPECIFIC RECOMMENDATIONS

4.1. OVERVIEW

This chapter leads to recommendations based on findings of the 16 case studies from 8 countries (Belgium, China, Czech Republic, France, Italy, Japan, Korea and Uganda) included in the "Collection of Case Studies" [2].

Those case studies do not completely cover all the aspects of the issue dealt with by this document. Hence, it is necessary to overview the issue and locate the case studies in the overall picture of the issue.

Urban transport problems are considered to appear as the following phenomena:

(1) Road traffic congestion particularly along roads in central urban areas or at bottlenecks,
(2) Unavailability of transport modes other than driving cars at origins or destinations of trips,
(3) High emission of green-house-effect/exhaust gas and noise,
(4) Traffic accidents, and
(5) Low accessibility to daily life services of people without good mobility alternatives.

In order to solve those problems, optimization of the use of road networks through better integration of different transport modes is considered as the key and it is given as the theme to be explored in this document.

The solutions should have effects as the following:

(1) Reducing car traffic on congested roads,
(2) Reducing use of cars running on fossil fuel as much as possible,
(3) Reducing traffic accidents, and
(4) Providing all the people with adequate and affordable mobility alternatives other than driving cars throughout the trip.

More specifically, the following measures are considered as solutions to those problems:

(1) Car-pooling and HOV/HOT lanes to increase the number of passengers in a car and to reduce car traffic,
(2) Improving service levels of public transport by exclusive bus lanes and improvement of transfer between public transport modes, which enhances competitiveness of public transport over private cars,

[2] In 2023, PIARC published the report "Collection of Case Studies" [1] from Working Group 2 of the cycle 2020-2023. The collection of case studies was conducted in two stages: the first stage was a survey of good practices aimed at collecting as many as possible worldwide, which was conducted from March to September 2021. The second stage was the development and collection of case studies. This was carried out from October 2021 till March 2022.

(3) Park and ride including park and BRT ride or park and expressway bus ride which connect car driving suited for low population density areas with riding on public transport entering the central areas of cities,
(4) Promotion of active modes including walking and cycling which are green and basic transport modes particularly at origins and destinations of trips,
(5) Development of MTCs which improves transfer between various transport modes and thus enhances service levels of public transport, which may include functions of car-pooling, park and ride and promotion of active modes, and
(6) Use of green modes of transport including e-cars, fuel cell cars, buses, railways, etc.

The case studies dealt with here cover the development of MTCs, dynamic bus lanes and car-pooling (HOV/HOT) lanes, and promotion of active modes. The recommendations presented in the following sections are limited to those measures.

For each section, we describe the findings from the Collection of case studies report and the specific recommendations inherent in them.

4.2. RECOMMENDATIONS ON MTCS

4.2.1. Several types of MTCs

There are several types of MTCs which correspond to their locations along the trips using them and the availability of other transport modes particularly rail transport with high speed and capacity.

One of those types consists of MTCs located at a railway station in city centers or inner-city areas. MTCs of this type provide easy transfer between transport modes. The transfer can be between railways and/or between railways and other modes. This type enhances the service levels of mode-mixes from the trip origin to the destination. This improves the competitiveness of the mode-mixes over driving cars throughout the trip, reducing car traffic. There are 4 MTCs of this type in the Collection of case studies report.

The second type comprises MTCs located at a railway station in the middle or near the suburban end of the trip route where people transfer from transport modes suited to less densely populated areas, e. g. private cars and buses, to railways that are suited to densely populated areas. The case of park and express-bus ride is included in this type although the MTC is simple with car parks and express-bus stops and is not located at a train station. There are 6 MTCs of this type in the Collection of case studies report.

The third type features small MTCs located at nodal points, e. g. train stations or carpooling line junctions, near to trip origins. This type provides people with a wide range of alternative modes of transport by locating MTCs within a reasonable distance from the origins of trips and the use of private cars is minimized. It incorporates ICT to provide an integrated mobility service to people through mobile phone applications.

4.2.2. Recommendations on MTC development at railway stations and express-bus stops

4.2.2.1. Findings for MTCs in the city centers or inner-city areas

- Three MTCs in case studies from China (Shenzhen and Chongqing) and Japan (Kitakyushu) are located at city centers. The MTC from Belgium (Brussels) is located in the inner-city area.

- Three MTCs in Shenzhen, Chongqing and Brussels were developed closely with regional transportation infrastructure. The MTCs in Shenzhen and Chongqing were developed at the same time as high-speed rail lines opened. The MTC in Brussels has direct train access to Brussels Airport and has made the access of people around the connecting lines to the airport easier.
- The MTC in Kitakyushu involves the redevelopment of a railway station building, extension of a monorail line into the railway station building and integration of its station with that of the railway. This has significantly improved the transfer between the railway and monorail.
- The main benefits and impacts of the MTCs lie in making transfers between modes easier. Transfer is mainly between a railway and various modes leading to the destination. They include shortening of physical distances, introduction of facilities such as escalators and elevators, synchronizing timetables and fare reductions for transferring trips.
- They also provide sufficient capacity of transfer and parking facilities including bus bays, taxi bays, taxi parking, car parking and bike parking.
- These improvements enhance ridership of public transport connected to the MTCs.
- The MTCs within the case studies from China feature three-dimensional utilization of space and the introduction of commercial and service functions. This has contributed to more efficient use of limited land in city centers.
- Inner-city MTCs contribute to the improvement of mobility within the city where they are located and to national or regional functions outside the city.

4.2.2.2. Findings for MTCs at an intermediate or suburban location along the trip route

- MTCs are sometimes located between a city center and suburbs. Five case-studies are compiled from Kunshan (China), Osan (Korea), Toyama (Japan), Nagoya (Japan) and Prague (Czech Republic).
- Among the five cases, three (Kunshan, Osan and Prague) were initiated by the location of new suburban rail stations or substantial renovation of existing suburban rail stations. The other two cases were initiated by the installation of new road-based feeder public transport systems and/or the addition of direct access link of an existing feeder system to rail station.
- The case of Kunshan presents 3 new MTCs at new stations on an extended section of a subway. With P+R (park and ride), bus and urban rail transit transfers and public bicycle connections, they attract passengers to the city center from the surrounding areas. Regarding the case of Prague, a new suburban rail station was located and new tram access to the station was provided. A joint tram-bus stop was built directly next to the train platform for easy and efficient transfer, and the interval of the existing tram system was shortened. The case of Osan is a substantial renovation of a suburban railway station, consolidating subway, buses (inter- city and local) and taxis. The two-storied MTC was built over the existing rail tracks.

- Regarding the latter two cases, the characteristics of a road-based feeder system are somewhat different. In Toyama, an existing railway branch line was converted to an LRT system by utilizing existing rail tracks and introducing new LRT fleet (phase 1), and MTC was formed by adding a new access link directly connecting to the railway station (phase 2). In Nagoya, a new elevated structure with low guide fence was built over the existing suburban streets, with a Guideway-bus (GWB) installed with low guide-wheels running on the elevated exclusive structure, without maneuvering. MTCs were located for transfer at both ends of the GWB system; one at the railway station and the other at the local bus terminal.
- Suburban MTCs contribute to more efficient use of road network by (i) increasing public transport users, and (ii) reducing car traffic towards the city center. In addition to feeder public transport stops, taxi pools and bike depots are consolidated in most suburban MTCs,
- Suburban MTCs contribute to the efficiency, environment and sustainability of the city concerned.
- Suburban MTCs attract more passengers and activate commercial and other land use in surrounding areas.
- A case study in a suburban part of Paris, France, has successfully promoted the use of express buses for commuting by providing park-and-ride facilities at motorway bus stops.

4.2.2.3. Recommended actions and considerations

- Since the railway system constitutes the trunk public transport system, improvement or development of MTCs at key stations in inner cities and at suburban stations is recommended in cities served by a railway system. MTCs in inner cities aim to (i) improve mobility within the city and surrounding areas, (ii)enhance the use of public transport connected to the MTC, and (iii) contribute to the more efficient use of road network. MTCs at intermediate or suburban stations aim to (i) consolidate trunk and feeder public transport system, (ii) enhance the use of public transport and (iii) contribute to the more efficient use of the road network.
- The effects of MTC development will be further enhanced when accompanied by improvements to the service levels of the railway system.
- It is noted that MTCs at intermediate or suburban stations provide people living in less densely populated areas with alternative mode-mixes to driving cars throughout their trips by connecting modes which are suited to less densely populated areas (such as cars and buses) with railways which are suited to densely populated areas, providing access into the city centers.
- For MTCs in inner city areas, three-dimensional use of land is recommended as this enables shorter transfer distances and the introduction of commercial and service functions.
- For MTCs at suburban stations, adding short access links from the feeder system to the railway station is highly recommended, as it enables easier transfers. Increasing the frequency of the feeder system and/or synchronizing the diagrams of the trunk and feeder systems are highly recommended. These measures are less costly in comparison to the installation of new feeder public transport systems.
- Installation of bike parking to enhance bike-and-ride is also recommended as it introduces both environmental and sustainability benefits.

- Public transport use can be encouraged by making transfers more convenient, e.g. P+R, bus-to-rail, public bicycle, etc.
- It is important to understand how "the last mile problem" can be solved by public transport rather than by car.
- Closer cooperation between public transport operators, unifying payment methods such as IC cards, and adjusting timetables to reduce waiting times would be highly effective.
- In the implementation stage of MTCs, coordination between central/local government and transport operators is required. In particular, coordination with the relevant urban planning authority in local government is recommended, to enable the proper and effective functioning of urban development around inner-city MTCs and suburban MTCs.
- For urban areas without an efficient rail transport system, providing park-and-ride facilities and/or operating local buses close to existing or new motorway bus stops would allow nearby residents to use the motorway without the need to build an interchange.
- The provision of dedicated bus lanes or HOV lanes on motorways is an effective way of encouraging the use of alternative modes to passenger cars.

4.2.3. Recommendations on small MTCs (Mobility Hubs)

4.2.3.1. Findings from case studies

- Two case studies (Ambérieu-en-Bugey (France) and Bologna(Italy)) on small MTCs indicate that small MTCs are located at train stations or carpooling line junctions on the trip route which are near to the trip origins. Usually, private cars are used as a means of transportation in these areas, but there is a need to use more eco-friendly modes. For this reason, these areas are introducing or planning small MTCs.
- In the example from France, small MTCs integrate all car sharing and carpooling services (line maps, etc.) as well as information about public transport (bus and train schedules, etc.) and alternative mobility (bicycle, electric car). They also offer other services including carpooling lines, parking lots and self-service bicycles. ICT in the form of mobile phone applications supports the carpooling services, etc.
- The example from Italy is in the planning stage, not yet an operational facility. It provides guidelines for the design and construction of small MTCs. Thirty small MTCs covering the whole metropolitan area are planned, mostly at railway stations. They provide adequate parking spaces for various vehicles (velo-stations, etc.) and electric recharging facilities, primarily for public and shared vehicles. They will also promote innovative and diverse services that utilize ICT including real-time information technologies.

4.2.3.2. Recommended actions and considerations

The installation of small MTCs at train stations or nodal points on the trip route which are near from trip origins is recommended.The aim is to (i) provide an attractive alternative mobility offer compared to using private cars, (ii) enhance the use of public transport, (iii) reduce emissions of green-house/exhaust gas and (iv) provide mobility opportunities to persons with disabilities and to people who do not have access to private cars. Providing user-friendly one-stop services using ICT is already operational and highly recommended.

4.3. RECOMMENDATIONS ON FLEXIBLE USE OF ROAD SPACE

4.3.1. Findings from the case studies

- Two case studies (Namur (Belgium) and Grenoble (France)) have demonstrated that the installation of a dynamic lane for buses and/or carpooling can help to encourage a modal shift from cars.
- The example from Belgium demonstrates a dynamic bus lane which converts a parking lane for residents and shop customers to a bus only lane during morning rush hours, installed on a main artery leading to the city center and train station.
- The example from France demonstrates a dynamic carpool lane installed on a highway, activated only during periods of highway congestion. In addition, the experiment (2007-2020) of a dynamic bus lane on the hard shoulder on the highway during rush hours was completed and the dynamic bus lane was changed to a permanent bus lane in 2020.
- The installation of a dynamic carpooling lane in the case study from France, made no impact on the extent of traffic congestion, but it must beconsidered that traffic levels have not yet returned to normal since the beginning of the COVID-19 pandemic.
- These case studies, which optimize space on congested roads and improve the speed of buses at low cost, can be implemented without the need to construct additional lanes. They improve the reliability of public transport and the resultant increase in bus/car occupancy is expected to reduce environmental impacts of travel.

4.3.2. Recommended actions and considerations

- The installation of dynamic bus lanes is recommended, with the aim of (i) producing a better quality of bus service during peak hours, (ii) enhancing the use of buses, (iii) reducing emissions of green-house gas and exhaust gas.
- The installation of dynamic carpooling lanes is recommended, with the aim of (i) reducing traffic congestion by increasing car occupancy, (ii) reducing the emissions of greenhouse and exhaust gases and (iii) reducing the cost of travel.

4.4. RECOMMENDATIONS ON THE PROMOTION OF ACTIVE MODES

4.4.1. Findings from the case studies

- In Prague, bicycle lanes have been installed, often at the expense of car transport, provided more space for bicycleswithout reducing the number of traffic lanes. The space occupied by a bicycle carrying one person is one tenth of the space required by a car carrying one person.
- In Kampala, Uganda, plans are in place to build a Non-motorised Transport (NMT) corridor on idle land along the railway line which leads to the center of Kampala.

4.4.2. Recommended actions and considerations

- Bicycle lanes and dedicated paths not only reduce journey times for cyclists, but also improve safety.
- Bicycle lanes also improve pedestrian safety as they eliminate the mixing of cyclists and pedestrians.
- Bicycle lanes are inexpensive, have a short construction period and only require appropriate traffic signage.
- Non-motorised transport (NMT) is the cheapest and most accessible mode of transport, and the provision of social services along the NMT corridor, such as schools, hospitals, libraries and

markets, has the potential to meet the mobility needs of all people.

- NMT corridor can be a model for cities without sufficient infrastructure for motorized transport if it proves to be successfully implemented.

5. CONCLUSIONS

Sustainable urban mobility is today, a priority for all city administrations and governments. Making cities less congested, cleaner and more ecological implies using all forms of transport more efficiently, limiting the use of private cars and developing multimodality.

In the last report of the 2016-2019 period[2], the committee examined the travel demand of residents in urban areas and the analysis of existing transportation networks. The report provides a series of good practices or recommendations on daily mobility:

a. *Consider the suitable size and scope of area for studies on mobility needs and transportation services (Chapter 1.2 "What do we mean by "urban region?") and understand the complexity of the relationship between spatial planning, demand, transport policies, ... (Chapter 1.3 "Complexity of urban transportation")*
b. *Focus on mobility needs of users (Chapter 2.2 "What are the daily needs of the inhabitants?"), control the impacts of long-distance trips on the organization of the transport system (Chapter 2.3 "Consequences of transport demand on transportation strategies and policies") and examine a multimodal approach that considers service level of multiple transport modes (Chapter 2.4 "Road Multimodal Level of Services")*
c. *Present diverse and varied mobility solutions based on the collective systems to be performed (Chapter 3.2 "Bus priority and BRT manual"), on a new use of traffic lanes (Chapter 3.3 " HOV, HOT, Managed Lanes"), on the strategic role of connection points (Chapter 3.4 "Multimodal Transit Centers") and on the impacts that the breakthrough of new shared services could have (Chapter 3.5 "New shared mobility")*
d. *Take into consideration all the reciprocal effects between transport and urbanization of the territory to achieve the best symbiosis (Chapter 4.2 "Transit Oriented Development").*

Recommendations were shared: "Present diverse and varied mobility solutions based on the collection systems to be performed, on a new use of traffic lanes, on the strategic role of connection points and on the impacts that the breakthrough of new shared services could have". To continue the reflection, the report asked for building an "accumulative database".

This is what has been achieved within this 2020- 2023 cycle: more than 41 good practices for optimizing road space have been selected, 16 of which are described in the "Collection of Case Studies" in terms of resilience, efficiency, and sustainability as well as the analysis of 16 surveys about general guidelines carried out among some PIARC member countries in this Briefing Note.

One common strategy is Transfer Promoting Solutions, to reduce the carbon footprint. Solutions are emerging such as increasing the attractiveness of collective transport, encouraging active mobility, shared mobility, and the flexible use of road space for dynamic bus, carpool or bicycle lanes.

Another common strategy is the development of Multimodal Transit Centers (MTCs), irrespective of the existing modes of transport, their location or size. This point of connection between modes must be easily accessible, offer daily services and make the journey as simple and secure as possible for users.

We hope that this report and its recommendations on multimodal solutions for optimizing road networks, based on the policies and strategies of the different countries and feedback from case studies, will enlighten and feed into projects in all countries, whatever their level of development.

The road of tomorrow will have a major role to play in the mobility of goods and people. Faced with the challenges of climate change, roads will have to be more resilient, more shared, lower-carbon and provide the essential link between urban centers and outlying areas.

In PIARC's future work, multimodality and road optimization remain an important area to analyze to meet the challenges of tomorrow. The work will consist in providing a better understanding of the interactions between modes on the road, the sharing of the roadway (bus and bicycle lanes, pedestrians), analysing the restrictions to access the cities for cars and considering the most vulnerable road users as active modes.

TC2.1 also recommends considering the conclusions of the “Social equity and accessibility of transport systems” from the PIARC special project in the next TC. The work addresses the subjects of social equity (are all segments of the population served fairly) and social accessibility (are all geographic areas accessible to all who need it in an affordable way) applied to road infrastructure and road transport. This research seeks to capture and analyse the current status quo in terms of how road authorities are currently managing the accessibility of their road infrastructure, whilst implementing this in the most socially equitable manner possible.

To complement TC2.1 reports, several references can be found in the following:

1. Task Force B.2 Automated vehicles, Challenges and opportunities for road operators and road authorities – MTC of the future, next step.
2. Technical Committee 2.4 – Deliverable- Utilizing data to optimize road network operations – A PIARC collection of case studies: some useful new information about “Regional Integrated Transportation Information Systems RITIS” (pag16) – new opportunities related to real time application.
3. Task Force 4.1 Road Design Standards- Report on the “state of the art”par.4.3 – Traffic composition and multimodal consideration in road design standard.
4. Technical Committee 1.4 – Climate Change and Resilience of Road Networks – PIARC Collection of Case studies - The importance of the MTC for the resilience of the road transport and infrastructure network.

6. GLOSSARY

Term	Definition
BRT	Bus Rapid Transit
GBS	Guided Busway System
HOT	High Occupancy Toll (lane)
HOV	High Occupancy Vehicle (lane)
ICT	Information and Communications Technology
JR	Japan Rail
LRT	Light Rail Transport
MaaS	Mobility as a Service
MGP	Multimodal Good Practice
MTC	Multimodal Transit Centre
NMT	Non-Motorized Transport
VR2+	Carpooling and high occupancy vehicle lane (in France)
VRTC	Bus lane (in France)
VSP	Voie Spécialisée Partagée – a dynamic bus lane

7. REFERENCES

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