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About the ITF Mobility Innovation Hub

ITF's Mobility Innovation Hub helps governments to develop innovative policies for better transport in the face of uncertainty and rapid change. It scans for transport-relevant developments at the horizon of public authority foresight, assesses their potential impacts and highlights best practices for deploying effective policies.

Case-Specific Policy Analysis Reports

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Foreword

Innovative mobility services and vehicles are quickly changing the way people travel. Collectively, they have become known as “New Mobility”. But what characterises the phenomena to which this term is applied? And how much do they influence the daily lives of citizens? Transport policy makers around the world are grappling with these questions.

Good definitions are essential to understand, monitor and regulate New Mobility for the benefit of all. This report proposes a classification system for New Mobility services and vehicles that can be universally applied. It suggests a list of policy-relevant performance indicators that will allow comparisons in time and across different jurisdictions or countries.

They enable a common understanding and compatible categorisations that will help public authorities and private-sector companies, which provide most of the New Mobility services, to work together. Reporting of compatible data can help ensure optimal service and also light regulation.

This report is the first publication by the International Transport Forum’s Mobility Innovation Hub. The Hub was created with generous funding from Korea’s Ministry of Land, Infrastructure and Transport to help governments respond effectively to innovations in the mobility sector and develop innovative approaches to transport policy-making in the face of rapid change. My personal gratitude and appreciation go to Minister Won Hee-ryong for his unwavering support and his passion for better mobility.

I am convinced that this report can take the development of New Mobility to a new level and that future outputs of the ITF Mobility Innovation Hub will bring real improvements to the way we conceive and execute policies for better transport.

Young Tae Kim
Secretary-General
International Transport Forum

Table of contents

Abbreviations and acronyms 7

Executive summary 8

What is New Mobility? 11

Mapping New Mobility at the local, national and international levels 11
Guidelines for classifying New Mobility 12
A taxonomy for New Mobility services 14
A taxonomy for New Mobility vehicles 19
Matching service categories and vehicle types 23

Developing New Mobility performance indicators 24

Why measure New Mobility performance? 24
Potential performance indicators by category 27
Potential performance management challenges 38

Collecting data for New Mobility performance indicators 40

Approaches to reporting New Mobility data 40
Data reporting: New Mobility data formats 42
Public-private agreements for reporting New Mobility data 45

References 48

Figures

Figure 1. Mobility services spectrum 15

Figure 2. New Mobility services and the vehicle types that perform them 23

Figure 3. Portland's multi-modal New Mobility performance indicator 25

Figure 4. US Federal Transit Administration's tiered mobility performance metrics framework and policy objectives 27

Tables

Table 1. A taxonomy of the most common New Mobility vehicle types 19

Table 2. New Mobility performance indicators in five policy areas 28

Table 3. Sustainability indicators for New Mobility services 29
Table 4. Safety indicators for New Mobility services 32
Table 5. Utilisation indicators for New Mobility services 33
Table 6. Accessibility indicators for New Mobility services 35
Table 7. Equity indicators for New Mobility services 37

Boxes

Box 1. Privacy-preserving mechanisms for data reporting 42
Box 2. Mobility Data Specification application programming interfaces 45
Box 3. Data acquisition methods 46

Abbreviations and acronyms

AAM	Advanced air mobility
API	Application programming interface
CEN	European Committee for Standardisation
CO_2	Carbon dioxide
DRT	Demand-responsive transit
EDA	Economically disconnected areas
GBFS	General Bikeshare Feed Specification
GPS	Global positioning system
ICCT	International Council on Clean Transportation
ICE	Internal combustion engine
MaaS	Mobility as a Service
MDS	Mobility Data Specification
MPM	Mobility performance metrics
NeTEx	Network and Timetable Exchange
NUMO	New Urban Mobility Alliance
OSLO	Open Standards for Linked Organisations
ovkm	Operational vehicle-kilometres
pkm	Passenger-kilometre
PPM	Privacy-preserving mechanism
pvkm	Passenger-related vehicle-kilometres
SAV	Shared autonomous vehicles
SUMP	Sustainable urban mobility plan
SUV	Sport utility vehicle
TNC	Transportation network companies
vkm	Vehicle-kilometre
ZEV	Zero-emission vehicle

Executive summary

What we did

This report proposes a comprehensive classification of "New Mobility" services and vehicles that are changing the way people travel. It also identifies performance indicators to help set the right policies as New Mobility evolves. It sets out a framework to systematically collect and compare New Mobility-related data. Finally, the report examines how governments and private stakeholders can collaborate to improve their understanding of New Mobility and determine if and where policy interventions are needed.

Around 150 policy makers, New Mobility operators and transport professionals provided insights into this report through a survey for this study. A workshop with 15 experts consolidated the survey's findings and established the list of New Mobility performance indicators presented in this report. The report also heavily draws on previous ITF work, notably *Safe Micromobility* (ITF, 2020a), and available literature.

What we found

"New Mobility" is defined here as intraurban passenger mobility services and vehicles enabled by digital technology. The spectrum of these services is widening, and the pace has accelerated since 2020 and in the wake of the Covid 19 pandemic. New Mobility services provide value to many citizens by increasing travellers' options and providing affordable and convenient alternatives to traditional transport modes. However, they are also disruptive and create new challenges, such as creating complex regulations for public authorities and the need to balance their benefits with potentially negative impacts.

To ensure New Mobility services ultimately serve the public good, policy makers must gain the best possible understanding of emerging trends in urban mobility. This, in turn, requires evidence based on accurate data and meaningful indicators.

A first and essential step to obtaining relevant data is clearly defining and categorising the elements that constitute New Mobility.

This report proposes a classification system for both New Mobility services and New Mobility vehicles. The categories were chosen to also capture other mobility options, such as public transport or popular transport, thereby allowing comparisons and benchmarking.

New Mobility services are classified by the type of product or service delivered. The two major categories are ride services and fleet sharing.

New Mobility vehicles are grouped into three categories: micromobility, powered light mobility, and car- or van-like vehicles.

Setting policies and regulations for New Mobility in ways that support desired outcomes requires information on performance and hence tools to measure that performance. This report presents relevant indicators for evaluating how New Mobility contributes to policy objectives. It proposes standard calculation methodologies, data requirements and effective reporting frequencies for performance indicators in five policy areas, namely sustainability, safety, utilisation, accessibility and equity.

Not least, it requires a well-designed data reporting framework to collect the relevant information. Most of the data are held by the service providers. Public authorities need to find an effective way for service providers to report it. They can either request raw data and subsequently decide which indicators to measure based on the data received. Alternatively, they can articulate policy objectives, define indicators to monitor them, and then request only the necessary data from the operator. Finally, public authorities can also task third-parties with collecting and analysing data. With all approaches, concerns about privacy and commercial sensitivity need to be considered when framing data reporting.

New Mobility service providers operate in different cities, regions and countries and must report data to several public authorities. Likewise, public authorities receive data from several service providers. Seeking convergence towards a common terminology, compatible data structures and standardised syntaxes is therefore desirable for the sake of efficiency.

Different frameworks exist for data reporting by service providers to public authorities. Data reporting can be compulsory or the condition to obtain an operating permit. Service providers may also report some data voluntarily to obtain mutually beneficial outcomes, or offer to sell data if prevailing data governance regulations allow this. Public authorities must build on the existing options to choose indicators and data reporting frameworks that allow them to monitor New Mobility and other incumbent services and ensure that these support public policy outcomes.

What we recommend

Apply a comprehensive classification of New Mobility services and vehicles

When looking at the type of product or service delivered, New Mobility services should be organised around two service types: fleet sharing and ride services. Public authorities should also categorise New Mobility vehicles using three top-level categories (micromobility, powered light mobility, and car- or van-like vehicles). If these classifications are not applicable, public authorities could create an alternative one, taking into account essential characteristics. A classification system should provide functional definitions, avoid ambiguous terms and create a logical and consistent structure for comparing and grouping different New Mobility services according to features of interest. It should also be general enough to capture important differences between categories without creating too many minor categories that cause the classification system to be overly complex. It should be flexible enough to incorporate all existing New Mobility services and unknown future New Mobility services. Finally, it should not bias analysis, policy or competition in favour of any particular actor, business model or technology.

Identify relevant performance indicators for New Mobility services and use them to set and monitor policy

To be effective tools to set and monitor New Mobility services, indicators should be relevant to policy goals, tied to a specific regulatory or policy action, easily understood and communicated, and consistent across services and modes whenever possible. They also need to be based on continuously available data to enable the calculation of time series. Common indicators used by as many actors as possible have great benefits and establishing them should be a priority for governments and private sector. New Mobility operators would no longer need to create custom performance reporting programmes. Governments could easily compare how New Mobility performs across cities. Finally, standard indicators would enable international comparisons and enable lessons-learned from other countries.

Adopt a consistent reporting framework for data on New Mobility services

Public authorities should apply a consistent approach for data reporting to all New Mobility service providers in a jurisdiction. Wherever possible, a unified approach should be implemented across jurisdictions. This will make it easier for service providers to comply with the requirements in different cities or regions. Conversely, cities and regions will be able to use data received from different operators more efficiently. Convergence towards compatible data structures and syntaxes should thus be a priority for both governments and the private sector.

What is New Mobility?

"New Mobility" can be defined as the range of emerging services and vehicles where new technologies intersect with novel and existing business models and transform people's ways of moving, sharing and using transport (Cunningham and Carlsson, 2019; Slowik and Kamakaté, 2017). While some New Mobility services have been around for more than a decade, they are still relatively new compared to other mobility services. They are generally innovative in nature, though the same can be said for many public transport and informal transport or "popular" transport services (Global Network for Popular Transport, 2023).

In this report, New Mobility refers to any intraurban passenger mobility services and vehicles enabled by digital technology. The spectrum of services in New Mobility is widening, with the pace of change much accelerated since the end of the 2010s and in the wake of the Covid-19 pandemic. These new services provide value to many but are equally disruptive. Therefore, policy makers must stay ahead of emerging trends to support the public good proactively.

Mapping New Mobility at the local, national and international levels

Several research institutions, non-profits, corporations and multi-actor initiatives have sought to explore the emerging New Mobility ecosystem in the last decade, highlighting the relevance of New Mobility to understanding today's transport sector. These initiatives seek to characterise the New Mobility landscape and, in many cases, monitor its development.

High-level New Mobility mapping exercises include SAE International's *Taxonomy of On-Demand and Shared Mobility: Ground, Aviation and Marine – JA3163* (SAE, 2021), SAE International's *Taxonomy and Definitions for Terms Related to Shared Mobility and Enabling Technologies – J3163* (SAE, 2018), the International Council on Clean Transportation's (ICCT) *New Mobility: Today's Technology and Policy Landscape* (Slowik and Kamakaté, 2017), UC Berkeley Institute of Transportation Studies' *Shared Mobility Policy Playbook* (Shaheen et al., 2019), the EU Share North project's *Shared Mobility Rocks: A Planners Guide to the Shared Mobility Galaxy* (SHARE-North, 2021), which focuses on helping cities and urban regions understand and regulate new forms of mobility services. The media platform Micromobility Industries maps the state of the micromobility industry covering service providers, original equipment manufacturer's suppliers and other industry stakeholders in its *Micromobility Landscape* (Micromobility Industries, n.d.).

Fluctuo, a commercial mobility data processing and analysis provider in Europe, has partnered with several New Mobility operators and POLIS, the European network of cities and regions for transport innovation, to produce quarterly and yearly reviews of New Mobility services. Fluctuo's quarterly and yearly Shared Mobility Index provides a comprehensive overview of the status of most New Mobility actors and services in Europe (Fluctuo, 2022).

Other initiatives describe subsets of the New Mobility landscape and their state of play. These include the Meddin bikesharing world map (DeMaio et al., 2021), the demand-responsive transit (DRT) world map

(Foljanty, 2020) and New Urban Mobility Alliance's *New Mobility Atlas* (NUMO, 2022) that maps the dockless shared micromobility landscape in cities worldwide.

The data provided by these sources highlight the importance of monitoring New Mobility. For instance, the number of operating bikesharing services increased from 31 in 2006 to almost 2 000 in 2021 (NUMO, 2022). DRT services using algorithmic routing and pooling optimisation experienced an exponential increase over the last eight years, from practically no operations in 2012 to almost 400 running in 2020 (Foljanty, 2020).

Some countries have taken the lead in mapping the New Mobility landscape at the national level. For instance, the US Government has made progress in characterising New Mobility within its territory with publications by the US Bureau of Transport Statistics, comparing bikeshare ridership across the country for systems with docking stations (USDOT, n.d.). At a sub-national level, several US cities were pioneers in collecting data of ridesourcing data from operators. For example, in 2016, the Transportation Authority of the city of San Francisco, California gathered data from Uber and Lyft on transportation network companies' (TNCs) usage to estimate the number of TNCs' drivers operating in the city and the amount of vehicle miles travelled (SFCTA, 2017). Since 2014, the New York City Taxi and Limousine Commission has published data on individual taxi trips performed by yellow and green taxis and ride-hailing apps (NYC TLC, 2022). The United States has also collaborated with Canadian cities through the National Association of City Transportation Officials, using data collected yearly from major operators in the United States (NACTO, 2019). The North American Bikeshare and Scootershare Association also published a 2021 state of the industry report (NABSA, 2022). In Europe, the French Ecological Transition Agency, l'Agence de l'Environnement et de le Maîtrise de l'Energie, French rail company SNCF, Keolis and Mappy published three editions of *Observatoire des mobilités émergentes* (The Observatory of Emerging Mobility) between 2014 and 2020. The latest of these reports studies New Mobility in France, Germany, the United Kingdom and Spain (ADEME, 2020). Grant Thornton, Mobility City and Fundación IberCaja also released a paper analysing the current mobility landscape and the medium- to long-term challenges of sustainable mobility and the automotive sector in Spain (Grant Thornton, Mobility City and Fundación IberCaja, 2021).

Guidelines for classifying New Mobility

One of the primary aims of this report is to provide a comprehensive framework for classifying New Mobility services and vehicles to capture the similarities and differences between types while enabling comparisons with other, more established mobility services – principally public transport and taxis. Whereas public transport and taxis operate under mature service delivery models and well-defined, broadly accepted service and vehicle taxonomies, many New Mobility services do not.

New Mobility's wide range and diversity of services, vehicles, business models and service delivery models create a challenge for classifying them. Establishing a meaningful classification framework is also complicated because stakeholders may wish to emphasise different features according to their interests and objectives. Further, many New Mobility services and their underlying business models are still relatively immature and in flux. The boundaries between certain mobility services are shifting. This is likely to continue as technologies, business models and regulations evolve. Finally, whereas other, more mature mobility services, like public transportation or taxis, are governed under broad principles adopted across multiple jurisdictions, the rapid deployment of New Mobility services has led to more localised regulatory frameworks adopting ad-hoc definitions and service taxonomies.

Combined, these factors complicate establishing a single and broadly accepted classification of all New Mobility services. Sketching out the high-level contours and categories of the maturing New Mobility ecosystem is nonetheless vital to frame discourse around New Mobility services and allow public authorities to address them consistently and unambiguously in policy and regulation (SAE, 2021). This process should be guided by sound principles.

A classification framework should provide functional definitions, avoid ambiguous terms and create a logical and consistent structure for comparing and grouping different New Mobility services according to features of interest. It should be general enough to capture important differences between categories but should not create too many sub-categories that complexify the classification system. It should be broadly consistent with industry practice and existing literature. It should be flexible enough to incorporate all existing New Mobility services and unknown future New Mobility services and be useful across disciplines. Finally, it should not bias analysis, policy or competition in favour of any particular actor, business model or technology. (SAE, 2021)

The first step in designing a classification system for New Mobility is to establish standard definitions and concepts that are operator or business-model agnostic. For example, previous ITF work (ITF, 2017) and SAE JA 3163 (SAE, 2021) note that mobility services can be scheduled or on-demand – the former planned by mobility operators and the latter initiated by user requests. The concept of shared mobility – "the shared use of a travel mode that provides travellers with access to a transportation mode on an as-needed basis" (SAE, 2021) – may involve concurrent sharing (where several people share a vehicle at the same time) or sequential sharing (where people use the same vehicle one after the other). Business models may be business-to-consumer, business-to-business, business-to-government or person-to-person (SAE, 2021). For most terms and concepts characterising New Mobility services, SAE JA 3163 serves as a reasonable – though not canonical – basis.

The second step in designing a classification system for New Mobility is to determine what top-level features should characterise mobility services. These classes should be sufficiently flexible to classify existing mobility services as well as new and future services and vehicles. Entities' in-house priorities may shape how they approach classification. For example, consider a classification system developed by a public agency to design safety regulations for New Mobility services. If safety is their principal concern, the concept of risk should form the basis for classification. Vehicle mass and speed are then relevant facets of the concept or class of risk. In this example, it would be prudent to classify vehicles according to those features rather than the business model or the powertrain type. Such a classification system may have several categories for electric bicycles but group many small rideable vehicles with similar safety risk factors together in a single category. This approach was taken in the ITF's report *Safe Micromobility* (ITF, 2020a), which proposes regulations and policies to improve the safety of micromobility systems. Other classification systems might be oriented around other components of vehicle design, such as vehicle dimensions or space consumption, to design infrastructure and allocate road space. On the other hand, setting data reporting requirements would necessitate a differentiation between commercially- or publicly-operated New Mobility services and privately-owned vehicles, which does not occur in the safety-oriented classification.

New Mobility services could be classified according to any of the following features:

- vehicle type (e.g. bicycle, e-push scooter, car, van)
- vehicle physical features (e.g. size, width, mass, number of axles)
- vehicle operational features (e.g. maximum speed, powertrain type, zero-emissions vehicles, level of automation)
- vehicle ownership (e.g. private or shared)

- service delivery features (e.g. services provided, rental duration, dock- or parking-based versus free-floating, e-hailed or pre-reserved)
- business model features (e.g. ride-based, subscription-based, membership-based).

The third step in designing a classification system for New Mobility is to determine how to derive a taxonomy reflecting the organising principles for the classification. This step may involve setting boundary thresholds for features displaying continuous properties (such as speed or mass). These thresholds should represent a meaningful difference between categories rather than an arbitrary cut-off. For example, the speed thresholds for a micromobility classification system could be the average speed of other road users. This would produce categories for vehicles that are at least as fast as a pedestrian, then vehicles that are faster than a pedestrian but slower than a cyclist, and so forth, to create regulations around road space access. Similarly, when the features of interest are discrete or qualitative (e.g. business model, vehicle type), categories should be chosen to create groups that are as large as possible while still capturing the differences between categories relevant to the user.

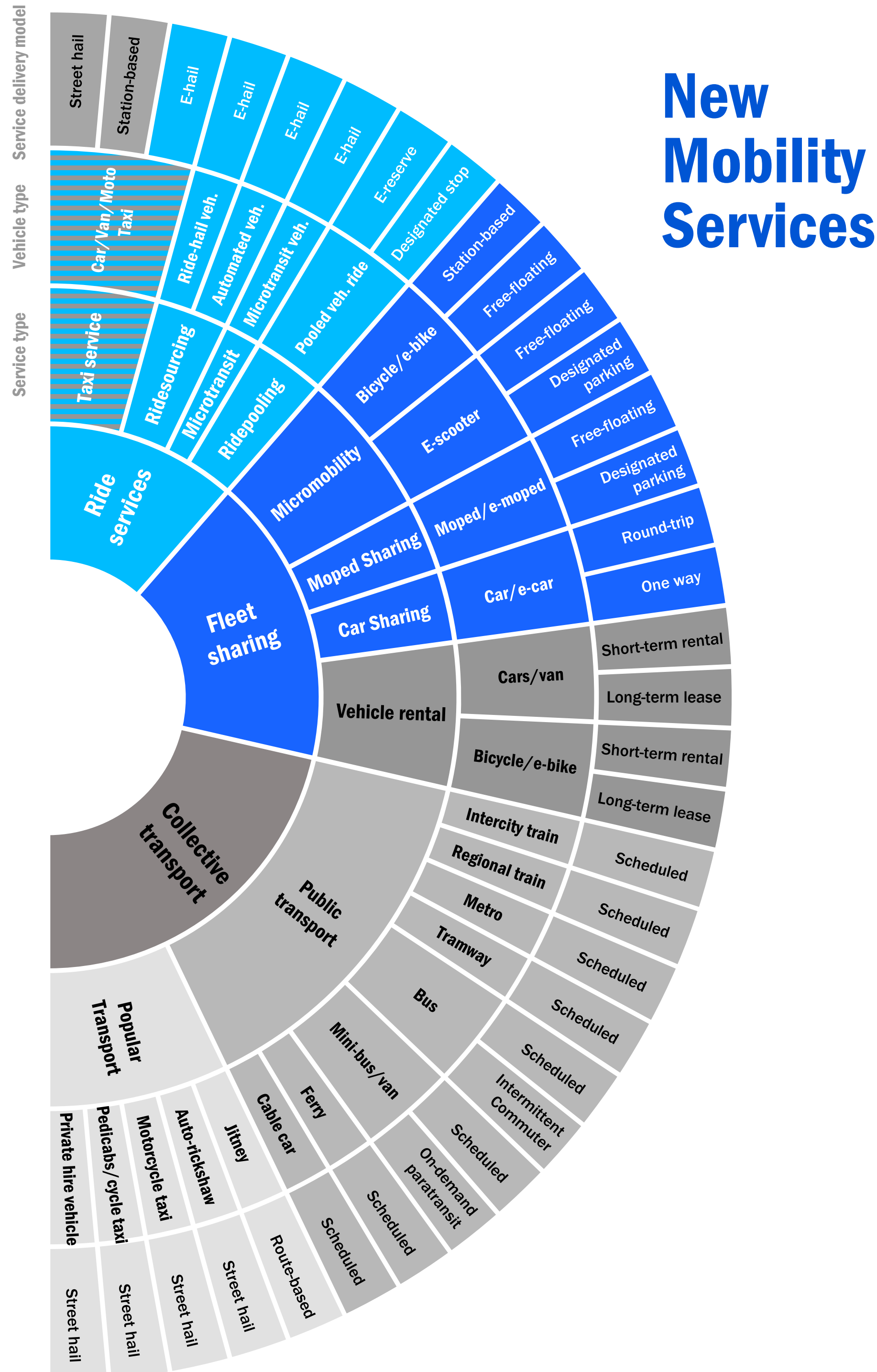
Finally, the classification system must have a hierarchy. In an enumerative classification system, the features should generally be ordered by importance to the user. For example, consider a classification system with two features: vehicle type and ownership. A transport planner may be most concerned about vehicle type and would therefore prioritise ordering the taxonomy by vehicle type and then differentiating between shared and private vehicles. On the other hand, a regulatory agency may be most interested in ownership first and would reverse the hierarchy's order.

A taxonomy for New Mobility services

This report aligns with SAE JA 3163 (SAE, 2021) and is organised around two service types: ride services and fleet-sharing, each divided into several sub-service types. It addresses the high-level features of the existing and emerging New Mobility landscapes. This breakdown reflects the type of product or service delivered (e.g. the organising “service concept”), such as a single ride in a platform-owned vehicle or a short-term vehicle rental. These service types and their sub-categories are sufficiently high-level to capture meaningful differences between all mobility services (including public transport and popular or informal transport) while still usefully characterising New Mobility services. This breakdown reflects that different mobility operators (e.g. public transport, popular transport, taxis and ridesourcing) offer the same product (e.g. a ride) in different ways. It also outlines where potential regulatory weaknesses may lie and, thus, where regulatory frameworks must be adapted to specific types of services (e.g. taxis versus ridesourcing or carsharing versus car rental).

Categorising by type of service creates a classification system that is technology- and vehicle-agnostic, allowing future New Mobility services to be included and compared against those that exist today. Nonetheless, changes in business practices among incumbent operators may warrant revisiting how public and popular transport are categorised. For example, taxis are highly regulated ride service types but, faced with competition from ridesourcing services, many have started offering e-hail ridesourcing. Likewise, popular transport providers may join digital dispatch platforms to increase revenues. There is also uncertainty over the long-term economic viability of certain service types; many New Mobility services have struggled to attain profitability across all markets where they operate. It may be that some New Mobility services may only be viable under very different market conditions (e.g. operating under public subsidy). If that were the case, their classification might shift.

Figure 1. Mobility services spectrum



Source: adapted from SAE (2021).

Figure 1 provides a snapshot of the current mobility service spectrum. It differentiates ride services, fleet sharing and various sub-configurations of each. It highlights consequential categories of New Mobility services and characterises the different roles of platforms, transport companies, contractors, and users in each service delivery model.

An emerging mobility service that is not included in the spectrum below is Advanced Air Mobility (AAM). AAM encompasses but goes beyond Urban Air Mobility and is "a broad concept focusing on emerging aviation markets and use cases for urban, suburban, and rural operations" (SAE, 2021). It includes passenger, logistics, and humanitarian use cases, including piloted or automated "air taxis". AAM can include different categories of New Mobility services (ride services and fleet sharing) and may operate in ways that are analogous to public transport (Cohen, Shaheen and Farrar, 2021). However, AAM services adopt a wholly different regulatory model than ground transport services. For this reason, they are typically addressed separately from the latter and are not covered in this report.

Ride services

SAE (2021) refers to ride services as "services that provide the traveller with access to rides where the traveller is the passenger and not the operator of the vehicle". It makes the distinction between for-hire ride services (e.g. those operated on a commercial basis) and not-for-hire ride services (e.g. those operated on a non-commercial basis between drivers and travellers with similar points of departure or destinations). Ride services broadly encompass many incumbent services (e.g. public transport, popular or informal transport and taxis) as well as New Mobility services. This section discusses only ride services that fall into the category of New Mobility services as outlined at the outset of this report: intraurban passenger mobility services and vehicles enabled by digital technology.

Ridesourcing

Ridesourcing is a ride service that provides a single pre-arranged or on-demand ride in a vehicle operated by an employee or contractor of the ridesourcing platform or in an autonomous vehicle owned or deployed by a platform. The vehicle operator acts as a chauffeur for passengers. The vehicle may be owned by the platform or the operator or leased from a third party. Vehicle operators (e.g. drivers) may themselves work for a contractor who contracts with the platform. Ridesourcing comprises three sub-categories:

- ride-hailing operators of cars, vans or powered two-wheelers
- shared autonomous vehicles (SAVs)
- taxis (for e-hailed taxi services).

Ride-hailing operators (sometimes referred to as TNCs) are currently the largest category of ridesourcing services by trip volume, having proliferated since their introduction in the early- to mid-2010s. This category includes the most well-known New Mobility service providers with hundreds of thousands of customers and large corporate valuations, such as Uber, DiDi, Lyft, Careem and Grab. Ride-hailing operators offer both private and shared rides, primarily in passenger cars. However, many providers also offer to chauffeur passengers on motorcycles (e.g. Gojek), electric three-wheelers (e.g. Bzzt) and other small passenger vehicles. Ridesourcing fares and price-setting mechanisms differ in some significant ways from similar services. Taxi fares are set according to established publicly available rules. Ridesourcing fares and prices are set according to proprietary algorithms that balance the supply of drivers and rider demand. This means that ridesourcing prices may adjust dynamically to attract drivers during high-demand periods. With the exception of dynamic fare-setting, many taxis are adopting app-based e-hail service models. Accordingly, some taxi service delivery models can be considered as part of "New Mobility".

Shared automated vehicles (SAVs) are a potential ridesourcing service type similar in practice to a ride-hailing service but with the important distinction that the vehicles are operated without drivers in certain designated areas. Several local authorities have recently granted licences to SAV operators to conduct pilot projects under strict geographic limitations while the technology remains in a developmental stage. These operators include Waymo and Cruise in the United States and Baidu and Pony.ai in the People's Republic of China. More broadly, there has been much speculation about the developmental timeline and impact of SAVs on the ridesourcing market and mobility systems. The hypothesis held by operators is that, by eliminating the labour cost associated with the vehicle operator and improving system efficiency, SAVs could offer low-cost ridesourcing compared to current services, thus attracting a considerable market share (Stocker and Shaheen, 2017). There remain serious questions regarding the technological feasibility and public acceptance of fully automated vehicle operation, especially in urban areas (ITF, 2018).

Microtransit

Microtransit (also known as demand-responsive transport or on-demand transport) is a type of on-demand multi-passenger ride-sourcing service typically transporting passengers in small buses or vans along flexible routes or at flexible times. Trips can be scheduled in advance or requested when needed. The micro-transit service may provide direct origin-to-destination service or pick-ups and drop-offs at designated locations. Microtransit services adapted for people with specific mobility needs have greatly improved travel options for those otherwise dependent on less flexible paratransit services. Microtransit often complements traditional fixed-route public transport services by providing access to and from stations. It also operates in areas with poor public transport service, a feature that gained importance following the Covid-19 pandemic as public transport agencies faced drops in ridership and revenues. Prominent microtransit operators include Swvl and Via. White-label software providers such as Bridj and Padam Mobility offer microtransit digital platform solutions. There are also emerging platforms such as Jetty, which introduce digital seat reservation and vehicle-dispatching tools for popular transport services, creating a microtransit-like technology-enabled service (Flores Dewey, 2019).

Ridepooling

Ridepooling (also known as ride-splitting) is a service that provides an open seat for a single trip in a privately-owned vehicle operated by another user of the platform. Unlike ridesourcing, the passenger and driver share similar or complementary destinations, and the vehicle operator is neither an employee nor a contractor for the platform. The vehicle is owned by the user of the platform. When using a private ridepooling platform, the passenger pays a fee per ride, which is then split between the driver and the platform. In some cases, private ridepooling platforms are subsidised by public agencies, corporations or institutions to reduce emissions and road congestion in their communities. Ridepooling serves a relatively small market compared to ridesourcing. Ridepooling services can be categorised by vehicle type: carpooling and vanpooling platforms, and motorcycle-pooling platforms.

Carpooling platforms connect passengers with drivers in typical passenger vehicles such as cars, trucks or vans. There are many private platforms, often operating in a limited geographic area. These include BlaBlaCarDaily, Karos and CityGo (France), RideAmigos (North America), TwoGo (Germany) and Moovit (Israel). There are also intercity carpooling platforms, which fall outside this report's scope.

Motorcycle-pooling platforms like QuickRide and RedBus' rPool service have also emerged recently in India. Through a mobile application, motorcycle-pooling platforms connect a motorcycle operator with a single passenger who sits on the back of the motorcycle.

Fleet sharing

Fleet sharing refers to services that provide temporary access to vehicles owned by a platform. The customer operates the vehicle themselves for one or more trips and then returns or parks the vehicle. Fleet sharing includes shared micromobility vehicles. There are four significant sub-categories of fleet-sharing services: bicycle and e-bike-sharing (including cargo bikes); e-scooter-sharing; moped and e-moped-sharing; and carsharing.

Bicycle and e-bike sharing

Bicycle and e-bike-sharing platforms were among the earliest New Mobility services to be established, with smart-card-based systems arriving in Europe in the 1990s. There are now over 1 000 cities worldwide with at least one bikeshare platform. Bikesharing systems provide short-term rental of a bike or e-bike.

There are two main categories of bikeshare systems: docked and dockless. Docked bikeshare systems have fixed stations where bikes must be picked up and dropped off and are typically operated directly by local governments or private operators under a contract defining required service levels. They are generally partially or fully subsidised. Some docked systems offer only pedal cycles, while others also offer e-bikes. Docked systems typically offer a flat rate for a single trip within a certain time limit or a subscription model that allows subscribers to take a limited or unlimited number of trips, also under a certain time limit.

Dockless bikeshare systems have free-floating geo-localised bikes and e-bikes. These bikes can be dropped off at any suitable location (e.g. a public bike rack or designated bicycle parking space) and are typically operated by private companies. Hybrid models also exist where bikeshare operates either as a dockless or docked system depending on the type of bicycle (e.g. e-bike versus pedal bicycle) or zone (e.g. central or peripheral). Dockless systems are more likely to be priced on a time or distance basis rather than a flat rate per use. Leading dockless bikesharing platform operators include Tier, Dott and Lime. Over time, dockless bikeshare systems have offered more and more e-bikes, especially in Europe and North America.

E-scooter sharing

E-scooter platforms are a more recent type of New Mobility service that have experienced tremendous growth over the past decade and are expected to continue to grow. These platforms allow for short-term rent of an electric scooter, usually for a time or distance-based fee. Unlike bikesharing platforms, e-scooter-sharing platforms are almost exclusively offered as dockless systems with designated drop-off areas. In some instances, however, e-scooter platforms operate with docks or designated, geo-fenced parking bays. E-scooter-sharing platforms are less likely to receive public sector subsidies. Many of the same operators provide both dockless bikesharing and e-scooter-sharing services, including Lime, Dott and Tier, while others like Voi offer e-scooters exclusively.

Car and moped sharing

Car- and moped-sharing platforms grant customers access to a motorised passenger road vehicle for a time-based fee. Vehicles are typically located on a mobile application via GPS. They may be dropped off at any suitable or designated parking location. Carsharing vehicles operate either on a round-trip model (they must return to where they were picked up) or on a one-way model (they can be dropped off at another designated or freely chosen location within a designated geographic perimeter). As they operate on the roadway in mixed traffic, proof of a valid driver’s license is required to hire a vehicle for which a licence is necessary. Moped-sharing is similar to e-scooter-sharing and bikesharing in that it is typically priced by the minute and often used for one-way trips.

Many carsharing platforms offer vehicles for rent by the hour or day. Carsharing co-operatives emerged in the 1940s in Europe and transformed into commercial operators in the 1990s (e.g. Mobility Carsharing in

Switzerland in 1997). Some carsharing services are still operated under a peer-to-peer model (wherein car owners rent out their vehicles when they are not using them), now enabled by a digital platform (e.g. Cozywheels). North American carsharing emerged primarily as a commercial venture in the 2000s (e.g. ZipCar in 2000). SHARE NOW and Zipcar (owned by Avis) are the market leaders in Europe and North America, respectively. Incumbent vehicle rental market actors (e.g. Europcar) are starting to offer short-term carsharing services to compete with new carsharing platforms. Popular moped-sharing operators include Cityscoot, Revel and Yego.

Long-term vehicle rentals, often used for inter-urban and holiday travel, do not fall within the definition of New Mobility for this report. Traditional car rental services offered by companies like Avis and Enterprise and newer peer-to-peer carsharing platforms like Turo fall into this category, as do day- or week-long bicycle rentals. In the future, however, long-term vehicle-sharing subscriptions may become more prevalent for daily intraurban travel as car owners give up their cars for this service as a means of minimising car maintenance and the risk of theft. Bike companies have tried the same method. Swapfiets, a Paris-based commercial bike leasing company, and Veligo, a publicly-owned electric bicycle and cargo bike leasing scheme in the Ile de France region, offer long-term bicycle leases via subscription. The fee includes the rental, cost of maintenance and theft insurance. The hope is that users will purchase e-bikes after trying them.

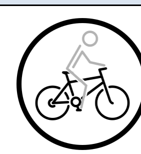
A taxonomy for New Mobility vehicles

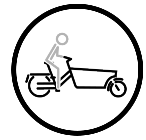
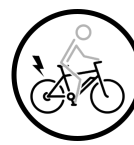
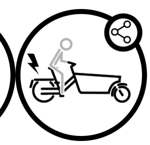
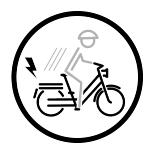
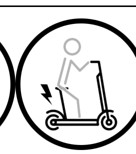
Table 1 provides definitions of existing and emerging New Mobility vehicles. It provides an overview of the diversity of form factors and serves as a guide for terms used in the remainder of this report. Several broad types of vehicles were identified and grouped into three top-level categories:

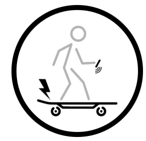
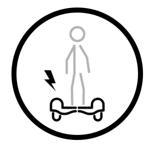
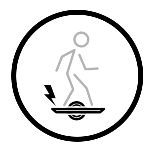
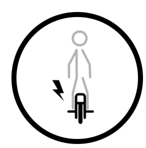
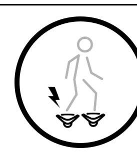
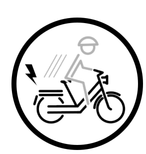
- micromobility
- powered light mobility
- car or van-like vehicles.

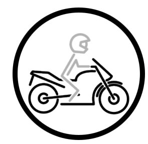
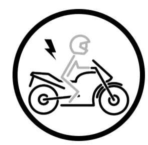
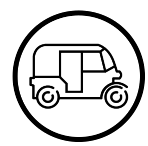
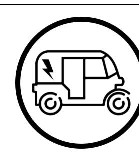
The definitions for micromobility and powered light mobility vehicles in Table 1 are largely based on the report "Safe Micromobility" (ITF, 2020a) and SAE Recommended Practice "Taxonomy of Powered Micromobility Vehicles" (SAE, 2019). Table 1 defines the most common vehicle types for each category.

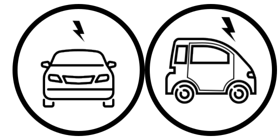
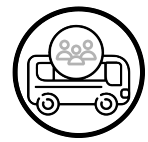
Table 1. A taxonomy of the most common New Mobility vehicle types

Micromobility	
Bicycles	
Bicycle (bike, cycle) A road vehicle that has two or more wheels and is generally propelled by the muscular energy of the persons on that vehicle, in particular by means of a pedal system, lever or handle (e.g. bicycles, tricycles, quadricycles and carriages).	

Cargo bike A bicycle designed as a load- or passenger-carrying vehicle – e.g. cargo-bike – in two- or three-wheel configurations.	
Pedicab (cycle rickshaw) A rickshaw-like pedal-powered vehicle able to carry two or more passengers.	
Electric bicycles (e-bike) An electrically assisted or electrically propelled bicycle-like vehicle. Regulatory distinctions regarding different classes of e-bikes are typically based on speed and whether the rider must be pedalling for the electric motor to engage.	
Pedelec (slow e-bike, Class 1 pedal assist bike) A type of pedal-assisted bicycle where the electric assistance cuts off when the vehicle reaches approximately 25 km/h (exact limit depends on local regulations). A pedalec only provides assistance when the user is pedalling.	 
Speed-pedelec (fast e-bike, Class 3 e-bike, speed pedal-assisted e-bike) A type of pedal-assisted bicycle where the electric assistance cuts off when the vehicle reaches approximately 45 km/h (exact limit depends on local regulations). A speed-pedelec only provides assistance when the user is pedalling.	
E-pedicab (e-cycle rickshaw) A rickshaw-like electric-assisted pedal-powered vehicle able to carry two or more passengers.	
Scooters	
Standing scooter (kick-scooter, push scooter) A human-powered street vehicle with a handlebar, deck and wheels propelled by a rider pushing off the ground. Models exist with two, three or four wheels. Standing scooters are distinguished from skateboards by the presence of a central control column and a set of handlebars.	
E-scooter (standing electric scooter, powered standing scooter, seated electric scooter, powered seated scooter) A stand-up or seated scooter propelled by an electric motor, irrespective of the user kicking.	 
Mobility scooter An electrically powered vehicle specifically designed for people with restricted mobility, typically those who are elderly or disabled. The term scooter is used in reference to the flat vehicle frame and the foot platform.	

Other Rideables A small, single-rider vehicle designed to be ridden by one person.	
Skateboard A rideable board with four wheels on two axles, propelled by the user kicking against the ground.	
Electric skateboard (powered non-self-balancing board, electric board, e-board, e-skateboard) A skateboard powered by an electric motor controlled by a hand-held throttle.	
Hoverboard (powered self-balancing board, self-balancing board, electric personal assistive mobility device—when it has a centre column and handlebar) A self-balancing micro-vehicle consisting of two motorised wheels connected to a pair of articulated pads on which the rider stands. The rider controls the speed by leaning forwards or backwards, and the direction of travel by twisting the pads.	
One-wheel A self-balancing electric personal transporter on which the user stands and places feet perpendicular to the direction of travel on front and back platforms.	
Electric unicycle (EUC, yuke, uni) A self-balancing electric personal transporter with a single wheel. The rider controls the speed by leaning forwards or backwards and steers by twisting the unit using their feet. Some dual-wheel models exist, but the principle remains that of a single-axle device used with feet in the direction of travel.	
Electric skates (e-skates, powered skates) A pair of skates with electric batteries and motors, controlled by the user leaning forwards or backwards or using a remote control.	
Powered light mobility	
Throttled e-bike ("twist and go" e-bike, scooter-style electric bike, low-speed throttle-assisted electric bicycle, throttle on-demand bike) A light bicycle-like two- or three-wheel vehicle able to operate with no pedal action solely on the impetus of a throttle-controlled electric motor. Maximum speed and electric motor power ratings vary according to applicable regulations. Throttled e-bikes able to travel above 25 km/h (exact limit depends on local regulations) are often regulated as mopeds.	

Moped A powered street vehicle with two or three wheels and a seat, sometimes equipped with pedals. When powered by an internal combustion engine, its capacity is typically limited to 50 cc. Maximum vehicle speed depends on national regulations but is typically limited to 45 km/h. Number plates are imposed in some countries and on some classes of mopeds.	
E-moped A moped powered by an electric motor.	
Motorcycle (motorbike) A powered street vehicle with two or three wheels and a seat, designed to reach speeds greater than 45 km/h.	
E-motorcycle A motorcycle powered by an electric power motor.	
Rickshaw (auto rickshaw, tuk-tuk) A small motor vehicle designed for transporting passengers or goods, typically with three wheels and a covered passenger compartment.	
E-rickshaw (e-auto rickshaw, e-tuk-tuk) A rickshaw powered by an electric motor rather than a combustion engine.	
Car and van-like vehicles	
Internal combustion engine (ICE) car or van (private car) A common consumer motor vehicle used for private passenger transportation, taxi services and ridesourcing. Includes variations such as pick-up trucks, minivans, sedans and sport utility vehicles (SUVs) that are primarily used for private transportation of passengers. ICE cars can be powered by internal combustion engines operating on fossil fuels, biogas or hydrogen.	
Hybrid car or van (hybrid electric car) A passenger car powered by an internal combustion engine and one or more electric motors for greater fuel efficiency.	

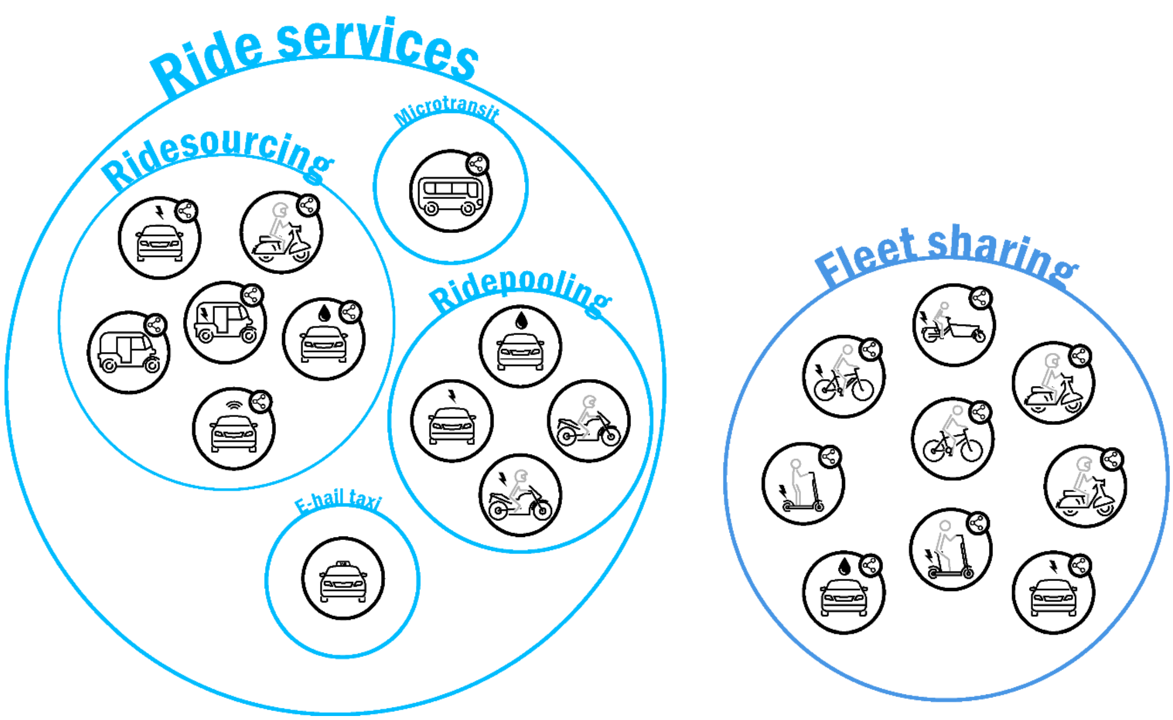
Battery-electric car or van (electric car) A passenger car powered exclusively by an electric motor. Zero-emission vehicles (ZEVs), electric cars that runs completely on electric power, are included in this category, as are micro-ZEVs, an emerging type of inexpensive, compact electric car.	
Automated car or van (autonomous car, self-driving car, driverless car) A type of passenger car-like vehicle that uses vehicular automation combining sensors, actuators and advanced types of algorithmic decision-making to operate in a given environment safely with little or no human input (SAE Level 4 or 5).	
Minibus (jitney, microbus, taxi-bus) A motor vehicle designed to carry a moderate number of passengers, typically between 12 and 30 people, used by private and public transport services.	

Source: ITF (2020a), SAE (2019).

Matching service categories and vehicle types

The New Mobility service categories outlined in Figure 1 can be specific to a single vehicle type or offer many different types of vehicles. Similarly, a specific vehicle type could be available across many different services. Figure 2 connects New Mobility services with the most common vehicle types used to perform those services. This is intended to be an illustrative representation only, not a comprehensive inventory. There may be service-vehicle connections now or in the future that are not indicated in this figure.

Figure 2. New Mobility services and the vehicle types that perform them



Developing New Mobility performance indicators

Developing policies and enacting regulations to ensure a safe, clean, efficient and equitable transport system is a critical component of government mandates to improve quality of life. Policy makers' ability to proactively plan for and shape a rapidly changing transport system, rather than reacting to new developments, will largely determine the environmental and societal outcomes of New Mobility modes and how they interact with other essential transport services. This section aims to help policy makers, local authorities and national governments choose effective New Mobility performance indicators to establish or improve their New Mobility policies and regulatory programmes.

Why measure New Mobility performance?

When the public sector adopts a vision-led "decide and provide" approach (wherein transport infrastructure and services are supplied to meet agreed-upon policy outcomes), New Mobility services can improve the quality of life for urban residents and visitors. However, when policy makers take a more reactive approach towards new business models and emerging services, they often fail to deploy or align regulations with desired outcomes. When regulators do not adopt coherent frameworks to regulate mobility services and vehicles, policies can result in more traffic congestion, higher levels of air pollution, tensions over the use of public space and reduced quality of life. For example, several large cities took a reactive approach to the disruptive emergence of ride-hailing services and micromobility platforms. Instead of carefully evaluating the benefits and externalities of these New Mobility services, cities reacted by banning operations altogether or making it difficult for them to function. Doing so led to a backlash from citizens (ITF, 2016).

The first step to building an effective New Mobility policy and regulatory programme is to assess New Mobility services in light of existing goals for the transport system. Examples may be those established in a sustainable urban mobility plan - SUMP (Eltis, 2019) or other urban mobility "vision" document. These plans or processes develop guiding visions for the transport system as a whole. If plans do not exist, they should be developed. If they do exist, they may need to be adapted to account for New Mobility services. For example, in 2021, the EU-based CIVITAS initiative published *Safe Use of Micromobility Devices in Urban Areas* (Figg, 2021), guidance on integrating micromobility services into sustainable urban mobility plans.

The second step to building an effective New Mobility policy and regulatory programme is to identify specific outcomes to which New Mobility services can contribute or which outcomes may be most at risk in the absence of adequate regulation.

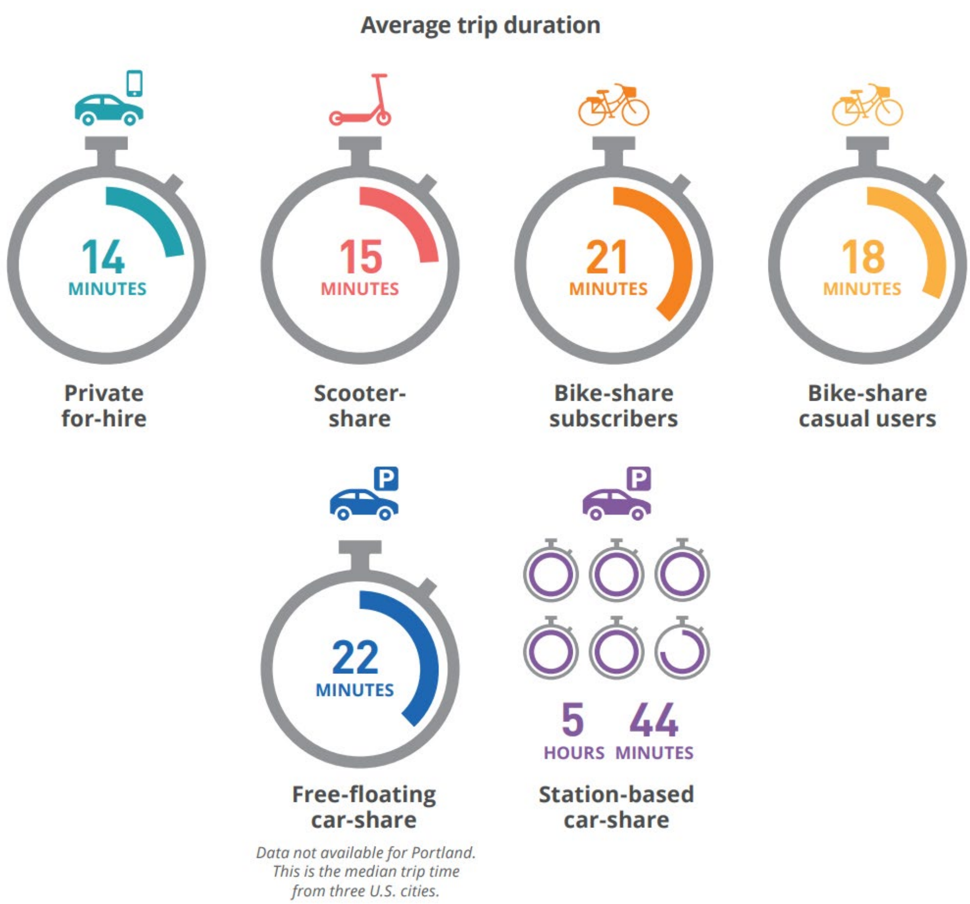
The third step is to determine how to measure progress in reaching the established desired outcomes or mitigating the identified risks.

Choosing effective performance indicators is critical for measuring progress. However, the ever-increasing data generated by New Mobility modes makes this a challenging task (ITF, 2022). On the one hand, performance measurement may seem daunting in light of the technical expertise and resources required to analyse large amounts of data from multiple New Mobility operators. Authorities may be discouraged from developing a robust performance management programme. On the other hand, the abundance of data might tempt some regulators to create unnecessarily complex and burdensome performance measurement programmes that go far beyond what is needed to serve the public interest. Finally, there is always the risk that the regulators may focus on services and activities producing digital data and neglect other "analogue" activities simply because gathering and processing data from the latter may be more complex than from the former.

A set of guidelines for selecting New Mobility performance indicators is needed. Effective New Mobility performance indicators should be:

1) feasibly calculable on a repeated basis
2) relevant to policy goals
3) tied to a specific regulatory or policy action
4) easily understood and communicated
5) consistent across services and modes whenever possible.

Figure 3. Portland's multi-modal New Mobility performance indicator



Source: PBOT (2020).

Many promising mobility performance indicators are currently in practice. For example, like many cities, Chicago, Illinois, in the United States, seeks to ensure that transport policies contribute to more equitable access. To that end, the city "identified geographies not currently well connected to regional economic progress (CMAP, 2019)." It refers to those areas as "economically disconnected areas" (EDA). The city uses two indicators to monitor equity: one calculates the percentage of ride-hailing trips that begin and end in an EDA and the other measures the length of trips serving an EDA. These indicators inform policy and investment decisions in line with desired equitability outcomes (CMAP, 2019). The government of Canberra, Australia, uses traffic violation notices and hospital admissions as proxy measures for the safety of its e-scooter pilot to ensure it is in line with over-arching traffic safety objectives (TCCS, 2021). Finally, the city of Portland, Oregon, in the United States, published its *New Mobility Snapshot* in 2020, incorporating car-based modes (e.g. ridesourcing, carsharing) and micromobility (bikesharing, e-scooter sharing) into a single performance evaluation programme with indicators for usage, sustainability and equity (PBOT, 2020). Figure 3 illustrates Portland's multi-modal performance indicator, i.e. the average trip duration by mode.

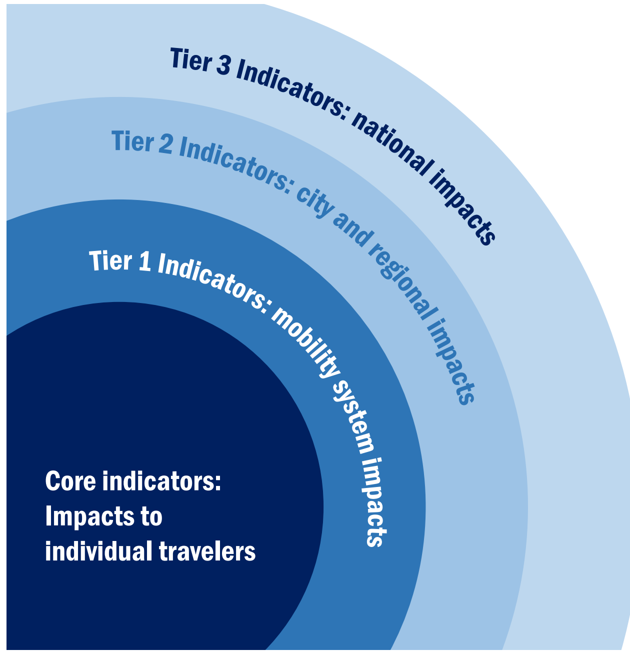
There is an infinite number of potential indicators for any given targeted policy outcome. Authorities must select the right indicators for their New Mobility performance management programme to be effective. They must also choose detailed calculation methodologies and measurement frequencies. Ideally, the indicators will be consistent across operators to enable a fair comparison of transport outcomes by New Mobility mode. However, choosing indicators that apply to a wide range of vehicles and business models can be difficult. Many governments take different approaches for the same indicator or area of policy interest. This creates inefficiencies and compliance challenges for operators operating in multiple jurisdictions. Moreover, different methodologies in different jurisdictions make it difficult to aggregate or compare the performance of New Mobility at the national or international level.

In an attempt to address this governance alignment challenge, the United States Federal Transit Administration released guidance on developing mobility performance metrics. The FTA (2020) report "Mobility Performance Metrics (MPM) for Integrated Mobility and Beyond" outlines a tiered framework for developing, categorising and selecting meaningful indicators and metrics, starting with those that are most important to individuals travelling (see Figure 4). It covers both new and incumbent mobility services and aligns relevant indicators across local, regional and national governance levels.

At the heart of the Federal Transit Administration's report, mobility performance metric framework are traveller-centric indicators that capture how well mobility services meet the needs of individual travellers. Three tiers of indicators measure mobility systems at different levels. Tier 1 indicators capture how well mobility services and the mobility system perform as they meet travellers' needs. These system-centric measures relate to system performance and efficiency, including local geographic accessibility performance. Tier 2 indicators capture the regional-scale secondary impacts of mobility services and the overall mobility system. They relate to regional economic, environmental, safety and social equity outcomes. Finally, Tier 3 indicators aggregate elements of previous tier indicators at the national scale. Tier 3 indicators provide a framework for developing and deploying national policies in line with the outcomes characterised and captured in the previous three levels. (FTA, 2020)

This framework helps align indicator development and tracking through all relevant governance levels. In Europe, the framework could be further extended to cover supra-national governance levels in areas where the European Union has an identified role.

Figure 4. US Federal Transit Administration's tiered mobility performance metrics framework and policy objectives



Source: adapted from (FTA, 2020).

Many New Mobility stakeholders would benefit from a set of common indicators. Operators would no longer need to create custom performance reporting programmes for each new service area. Regional and national governments could easily compare performance across all urban areas within their jurisdictions. Larger, well-resourced cities could easily share expertise and best practices with smaller cities if those cities used common performance indicators. Finally, standardised New Mobility indicators would enable compiling national and international databases, allowing the impact of New Mobility on global urban passenger transport to be better understood.

Potential performance indicators by category

Table 2 presents the list of potential policy-relevant indicators for the performance evaluation of New Mobility services to serve the public interest. This section proposes standard calculation methodologies, data needs and reporting frequencies for several performance indicators in five policy areas: sustainability, safety, utilisation, accessibility and equity. It associates each indicator with one or more policy actions and discusses the benefits and drawbacks of each indicator.

Table 2 does not address all possible indicators. Rather, it establishes initial starting points for implementing effective New Mobility metrics tied to specific policy actions. Indicators such as these can serve as the foundation for a robust performance management programme. Other indicators may also be relevant to address context- or actor-specific issues.

Crucially, these indicators help guide the development of New Mobility services and a means to monitor them efficiently. Nonetheless, many of the proposed indicators impose burdens on actors incentivised or required to report them to public authorities.

By their very nature, the indicators target a small subset of all mobility services and actors. At this stage in their development, and possibly for some time into the foreseeable future, New Mobility services represent a small share of overall trips, trip volumes and related impacts. For example, the marginal contribution of vehicle-kilometres travelled by ridesourcing may trigger higher congestion levels. Still, the overwhelming volume of personal vehicle and freight distribution travel is the main contributor to urban congestion. Likewise, poorly parked micromobility vehicles may be seen to contribute to urban clutter, but the main source of illegal or anarchic occupation of urban public space remains private cars and urban delivery vehicles (ITF, 2021a).

The imposition of reporting requirements linked to this or other indicator sets should account for the above. At the very least, indicators chosen to monitor the contribution of New Mobility services to specific policy outcomes should mirror analogous indicators tracking how other mobility services or travel contributes to those same outcomes. Ideally, generic indicators should be developed and deployed to monitor all mobility services and trips. There are instances where developing and deploying indicators specific to New Mobility serves policy goals – especially as these services are new and quickly developing. When this is the case, public authorities should clearly and transparently communicate why the indicators are only applied to New Mobility services.

Table 2. New Mobility performance indicators in five policy areas

Policy area	Indicator
Sustainability	1.1 Vehicle-kilometres and passenger-kilometres travelled 1.2 Average vehicle lifespan 1.3 Alternative mode replaced and trip generation effects 1.4 Operational CO_2 emissions
Safety	2.1 Injury rate 2.2 Crash rate 2.3 Share of passenger-kilometres travelled on low-stress routes
Utilisation	3.1 Vehicle utilisation rate 3.2 Trip distance (or trip duration for round-trip services) 3.3 Total users
Accessibility	4.1 Access latency 4.2 Number of trips starting or ending near essential services and opportunities 4.3 Vehicles or trips available by area (spatially aggregated) 4.4 Trip purpose
Equity	5.1 Vehicle and trip availability in targeted service areas 5.2 Number of trips starting or ending in targeted service areas 5.3 Vehicle and trip availability for users with physical disabilities

Sustainability indicators

Sustainability is a challenge for transport policy today. There remains a considerable gap between the desire of public authorities to monitor the sustainability impacts of New Mobility and their ability to do so

(ITF, 2021a). A significant challenge is determining the appropriate methodology and reasonable assumptions for computing environmental impacts, including CO_2 emissions.

Table 3 provides details on the sustainability performance measures from Table 2. Three of the four indicators included in this section are intended to be directly measurable (e.g. vehicle-kilometres travelled) in order to limit ambiguity and complexity while offering policy-relevant information.

CO_2 emissions are such an essential component of sustainability that Indicator 1.4 is dedicated solely to monitoring operational CO_2 emissions. A full account of environmental impacts should consider emissions and impacts over the whole lifecycle of the service, including upstream energy and end-of-life disposal impacts. ITF developed a framework and methodology for measuring New Mobility services' lifecycle energy and CO_2 impacts. They are presented in the report *Good to Go? Assessing the Environmental Performance of New Mobility* (ITF, 2020b). Some of the indicators below help feed into lifecycle assessments of energy and CO_2 (e.g. lifespan of vehicles and vehicle-kilometres travelled). Others should reflect the guidance outlined in the same report (e.g. operational CO_2 emissions).

Table 3. Sustainability indicators for New Mobility services

Indicator 1.1: Vehicle-kilometres and passenger-kilometres travelled	
Policy mandate	Monitor and/or limit urban congestion.
Policy action	Offer incentives or regulations to achieve an average vkm/pkm threshold. Note that individual thresholds should be set by mode. This indicator could also be used to assess the potential for distance-based fees.
Considerations	This indicator can be used to compare marginal contributions to congestion across all New Mobility modes. However, it cannot serve as a metric for overall congestion since most vkm do not involve New Mobility services.
Reporting frequency	Monthly or annually
Data needs	1. Passenger-related vehicle-kilometres (pvkm) for vehicles travelling with passengers, whether the vehicles are deployed in a fleet or operated by contractors. For ridesourcing vehicles, this measurement should commence when a trip is booked, not when the passenger has boarded, to account for passenger-related vehicle travel. 2. Operational vehicle-kilometres (ovkm) covering indirect vkm related to support vehicles involved in maintenance, rebalancing, charging and other routine operational tasks. 3. Total number of passengers or riders. 4. Total number of vehicles (split by passenger and operational vehicles).
Calculation method	<u>Total vehicle-kilometres (vkm)</u>: sum 1 and 2 above by vehicle class. Report overall vkm separately for pvkm and ovkm. <u>Average vehicle occupancy rate</u>: divide 3 by 4 (passenger-carrying vehicles) above. <u>Passenger-kilometres travelled (pkm)</u>: multiply pvkm by the average vehicle occupancy rate. <u>Average pvkm per pkm</u>: divide the total pvkm by the number of pkm travelled. <u>Average overall vkm per pkm</u>: sum 1 and 2 above and divide by pkm.
Examples in practice	San Francisco, California, in the United States, uses vkm as a performance indicator for ride-hailing companies (SFCTA, 2017), while São Paolo charges ride-hailing companies a dynamic fee based on mileage (Joshi et al., 2019).

Indicator 1.2: Average vehicle lifespan	
Policy mandate	Monitor and/or limit the total environmental impact of New Mobility, including waste generation.
Policy action	Offer incentives or regulations to achieve an average lifespan threshold. Note that individual thresholds should be set by mode.
Considerations	While this indicator is based directly on chassis replacement, the increasingly modular nature of many vehicles used for micromobility complicates this indicator's use for these services. Some convergence over what constitutes a "vehicle" in lifespan calculations may be necessary. Given the increasing importance of electric modes, battery lifespans could also be monitored. Considerations for sustainable recycling programmes should be included in any lifespan-based policy action.
Reporting frequency	Annually
Data needs	1. Start and end of service dates for each vehicle chassis when vehicles are retired. 2. Total pkm for each vehicle chassis retired.
Calculation method	Average lifespan: difference between start and end of service dates for each vehicle chassis retired in the period (in months) averaged over the total number of chassis retired in the period. Average pkm per month of lifespan: for each chassis retired in the period, divide the pkm the chassis served by the months of lifespan, then average over all chassis retired in the period.
Examples in practice	Voi, an e-scooter platform operator, has made vehicle lifespan information available to the public (Holm Møller and Simlett, 2020).
Indicator 1.3: Alternative mode replaced and trip generation effects	
Policy mandate	Promote an efficient and sustainable transport system.
Policy action	Introduce new regulations or invest in alternative modes if New Mobility is found to be replacing alternative modes with fewer social externalities.
Considerations	This indicator can compare modal shifts induced by all New Mobility modes, including private users of New Mobility vehicles (depending on the survey design). Traditional surveys are often expensive to conduct. However, application-based New Mobility services could propose the survey through the platform's interface.
Reporting frequency	Annually or at regular multi-year intervals
Data needs	1. Survey responses from a representative and statistically significant sample of New Mobility users.
Calculation method	Alternative mode replaced: count the number of trips that would have been taken by each alternative mode, with responses weighted to provide a representative sample of New Mobility users. Alternative modes in the questionnaire should include public transport (if available), walking, driving, cycling and New Mobility modes (with an option to indicate that the trip is an induced trip that would not have occurred if the New Mobility mode had not been available). This assessment should ideally capture full trip chains and not just the dominant mode used.
Examples in practice	Many cities, including Wellington, New Zealand (vehicle-sharing) and Boston, Massachusetts, United States (ride-hailing), have surveyed New Mobility users about alternative mode replacement (Wellington City Council, 2020; MAPC, 2018).

Indicator 1.4: Operational CO_2 emissions	
Policy mandate	Monitor and/or limit CO_2 emissions from transport.
Policy action	Offer incentives or regulations to achieve an average CO_2/pkm threshold. Individual thresholds should be set by mode. Offer incentives to increase the share of vkm that uses more environmentally friendly vehicles.
Considerations	This indicator can compare sustainability across all New Mobility modes. It relies on the average rate of CO_2 emissions per vkm, which may be difficult to verify or validate. In many countries, automotive original equipment manufacturers are required to report CO_2 and energy performance. Where this is the case, such figures should be used. Where such requirements do not exist, they should be considered for new vehicle types (e.g. electric scooters and bikes) in line with other energy and CO_2 reporting requirements for consumer goods. In the absence of official reporting requirements, third-party verification should be considered.
Reporting frequency	Monthly or annually
Data needs	1. Passenger-related vkm (pvmk) (for vehicles travelling with passengers deployed in a fleet or operated by contractors) and operational vkm (ovkm) (from support vehicles involved in maintenance, rebalancing, charging and other routine operational tasks) for each vehicle model. 2. Average CO_2 emissions per kilometre by vehicle model. 3. Total passenger-kilometres (to calculate the average emissions per pkm).
Calculation method	Total lifecycle CO_2 emissions: multiply the pvkm and ovkm by the average lifecycle CO_2 emissions per kilometre for each vehicle type in the operator's fleet. Average CO_2 emissions per pkm: divide the total lifecycle CO_2 emissions calculated above by the total pkm.
Examples in practice	ITF has developed a comprehensive lifecycle assessment methodology for capturing New Mobility services' CO_2 and energy intensities (ITF, 2020b). This can serve as the basis for other lifecycle assessments and has been used to develop certain operator-based lifecycle assessments of their services (Lime and Tier). Some operators, including Gojek and Uber (ridesourcing), as well as Tier, Voi and Lime (vehicle-sharing), already make CO_2/pkm available to the public in many markets (WEF, 2022).

Safety indicators

The safety impacts of New Mobility services are often a primary public concern when a New Mobility service is launched (ITF, 2020a). Safety performance is not evenly measured across modes. Generally, a relatively large amount of quality data is available for motorised modes like cars, vans, trucks and powered two-wheelers. However, there are far less available data for bicycles, scooters and other forms of micromobility. Road safety crashes for the latter are largely under-reported – especially for non-fatal crashes (ITF, 2020a).

The following three indicators estimate the public safety impacts of New Mobility by measuring injuries and road crashes, as well as users' perceptions of safety. Robust data reporting relationships with other stakeholders (e.g. law enforcement, hospitals and other health services) are critical for indicators 2.1 and 2.2. This set of safety indicators assumes that New Mobility operators already have established mechanisms to deter unsafe behaviour by the vehicle operator, such as speeding, parking in restricted areas and impaired or double-riding (for e-scooters).

There is ongoing work on micromobility safety to use fine-grained acceleration data to detect swerving and rapid deceleration, which provides direct evidence of unsafe behaviour or potential injuries (ITF, 2020a). Currently, crash-detecting sensors are rarely installed on vehicles to record crashes and they are not typically installed on private vehicles. Crash-detecting sensors generate large amounts of data that can be challenging to process. For this reason, the report does not include an indicator related to such sensors. Nevertheless, this area of research appears promising for future policy applications such as identifying safety hazards.

The perception of safety (and security) is an important factor to consider when establishing safety- or security-enhancing policies. This is not captured in the indicators below but should be explored later since safety- and security-enhancing policies may fail or underperform expectations if the result is perceived as less safe or secure than the current situation (ITF, 2013).

Table 4. Safety indicators for New Mobility services

Indicator 2.1: Injury rate	
Policy mandate	Ensure a safe transport system for all travellers.
Policy action	Address the danger posed by non-New Mobility service cars and trucks. Invest in targeted traffic safety improvements in risky areas. Introduce new regulations for unsafe New Mobility vehicles or enforcement mechanisms for unsafe behaviour. Improve communication of critical safety information for all drivers and New Mobility service users.
Considerations	This indicator can be used to compare the impact on safety across all New Mobility modes. Note that true injury rates for walking, cycling and scootering are often vastly underreported. In addition, it can be difficult to collect reports of minor injuries. Regulators should consider multiple injury data sources, such as injuries reported to the service operator, hospital or clinic admissions, and requests for emergency services.
Reporting frequency	Monthly or annually
Data needs	1. Total number of injuries (fatal and serious, as measured on a standardised scale, e.g. the Maximum Abbreviated Injury Scale or MAIS in Europe) resulting from the use of a New Mobility vehicle, and the location at which the injury occurred. 2. Number of people involved in a crash with a new mobility vehicle by road user category. 3. Total passenger-kilometres (pkm) per New Mobility service model.
Calculation method	<u>Injuries per pkm</u>: total number of injuries reported (fatal and serious) divided by the total pkm. <u>Distribution of injuries by the road user category of the crash opponent</u>: number of injuries reported (fatal and serious) by the road user category, the crash opponent, including self-crashes, divided by the total number.
Examples in practice	The government of Canberra, Australia, uses traffic violation notices and hospital admissions as proxy measures for the safety of its e-scooter pilot (TCCS, 2021).
Indicator 2.2: Crash rate	
Policy mandate	Ensure a safe and convenient transport system for all travellers.
Policy action	Introduce or modify regulations of key crash opponent vehicle class. Introduce new regulations or enforcement for New Mobility vehicles with high crash rates. Improve communication of regulatory and compliance information for users.
Considerations	This indicator can be used to compare the impact on safety across all New Mobility modes. Crash rates should be collected from law enforcement agencies or health authorities.
Reporting frequency	Monthly or annually
Data needs	1. Total number of traffic crashes involving the use of a New Mobility vehicle. 2. Total pkm per New Mobility service model.

Calculation method	Crashes per pkm: total number of crashes reported divided by the total pkm.
Examples in practice	The government of Canberra, Australia, uses traffic violation notices and hospital admissions as proxy measures for the safety of its e-scooter pilot (TCCS, 2021).
Indicator 2.3: Share of pkm travelled on low-stress routes	
Policy mandate	Ensure a safe and convenient transport system for all travellers.
Policy action	Implement ambitious speed management policies. Implement targeted urban vehicle access regulations. Make targeted investments in new separated infrastructure for light and micromobility modes. Improve directional indications for low-stress routes.
Considerations	This is a relatively complex indicator to compute as “stress” is perceived by a heterogeneous user base and is context-specific. For some, stress may only be related to the traffic environment, but for others, the perception of stress may also be linked to acts of violence, including gender violence. Perceived stress may also change over time as the travelling population becomes more skilled and comfortable with new travel behaviours. From a technical perspective, stress indicators are not necessarily straightforward to calculate since vehicle trajectories must be snapped to the road network. Stress indicators provide helpful insight into the traveller experience and enable targeted policy interventions, including infrastructure deployment.
Reporting frequency	Monthly or annually
Data needs	1. New Mobility traffic volumes by road segment and direction. 2. Network map identifying low-stress road segments for New Mobility users.
Calculation method	Perceived stress methodology: low-stress routes can be captured by several measurements. Direct surveys can capture peoples' perceptions of stress. Proxy indicators could also be used, such as the degree of separation between micromobility users and other road users, overall traffic volume per street segment, average vehicular travel speeds, etc. Share of pkm travelled on low-stress routes: multiply directional road segment volumes by the length of the road segment for all low-stress road segments. Divide the result by the product of road segment volumes and the road segment length for all road segments.
Examples in practice	Many cities set targets for increasing the use of low-stress routes, including Boulder, Colorado, United States (City of Boulder, 2019). The City of Calgary, Canada, uses GPS trajectories to plan dedicated infrastructure for micromobility (Kanygin, 2019).

Utilisation indicators

Understanding how and where people travel around a city is critical to maintaining an efficient transport system. The following indicators provide evidence for policy decisions around appropriate fleet sizes for New Mobility services and identify opportunities to encourage mode shifts towards sustainable travel modes. These indicators are measured directly and straightforwardly to calculate.

Table 5. Utilisation indicators for New Mobility services

Indicator 3.1: Vehicle utilisation rate	
Policy mandate	Maintain an appropriate fleet size to avoid cluttering public space while meeting transport needs.
Policy action	Allow increases or enforce decreases in fleet size based on utilisation thresholds.
Considerations	This indicator can be used to compare utilisation across all New Mobility modes. Weekdays and weekends could be determined separately. Seasonal effects are quite pronounced in some regions;

	therefore, policy thresholds for the fleet size set by public authorities should take into account specific policy targets. Caution should be exercised in tracking utilisation rates in the context of spatial requirements for fleet deployment. Where there are requirements to service a broad area, utilisation rates will decrease on average due to fewer trips in low-density or less central locations. Likewise, public authorities may want to incentivise fleet availability in targeted areas that may naturally have low utilisation rates. Low utilisation rates in those contexts may not necessarily reflect specific targeted public policy outcomes (e.g. access to vehicles for a targeted population versus efficient use of vehicles).
Reporting frequency	Monthly
Data needs	1. Total number of trips. 2. Active fleet size.
Calculation method	Average vehicle utilisation rate: divide the total number of trips by the total number of active vehicles in the reporting period and the number of days in that period. Take the average over the fleet.
Examples in practice	Many cities, including Santa Monica, California and St. Louis, Missouri in the United States, have adopted dynamic fleet size limits based on utilisation rate (ITF, 2021a).
Indicator 3.2: Trip distance or travel duration	
Policy mandate	Promote an efficient and sustainable transport system.
Policy action	Trip distance distribution and the share of short trips can be used to identify opportunities for incentivising mode shift to sustainable and active modes. Average travel duration statistics help gauge fleet size needs (e.g. for carshare or cargo bikeshare) as vehicles that operate on a round-trip basis are used for longer periods and are not available at a parking stand or dock.
Considerations	This indicator can be used to compare travel behaviour across all New Mobility modes.
Reporting frequency	Monthly
Data needs	1. Distance travelled for each trip. 2. Travel duration for each trip, disaggregated by service model (point-to-point versus round-trip).
Calculation method	Trip distance and travel duration distribution: calculate the average trip distance and travel duration, and relevant quantiles of the distribution. Share of short trips: count the number of trips under an established distance threshold (e.g. 4 km).
Examples in practice	Chicago, Illinois, in the United States, uses trip distance to inform policy making about the utilisation of New Mobility (CMAP, 2019).
Indicator 3.3: Total users	
Policy mandate	Promote an efficient and sustainable transport system.
Policy action	Understanding the popularity of New Mobility services over time can inform fleet size limits and future mobility services planning.
Considerations	This indicator can be used to compare utilisation across all New Mobility modes.
Reporting frequency	Monthly
Data needs	1. Number of unique active users with at least one trip in the period.
Calculation method	Total users: take the sum of the unique active users.
Examples in practice	The city of Seoul, Korea incorporates the monthly users' indicator into their bikesharing performance analysis (Cho, Seo and Kim, 2021).

Accessibility indicators

The concept of accessibility is increasingly used to evaluate transport systems and inform decision-making (ITF, 2022). Accessibility is not to be confused with mobility. Accessibility indicators measure the number of opportunities that people can access in a given time or distance, whereas mobility focuses on travel speeds and distances, not the reason behind the travel. The indicators presented in this section are related to trip purposes and destinations, as well as the availability and convenience of New Mobility services for pursuing those trips. These indicators provide policy makers with deeper insights into how effectively New Mobility services allow residents to pursue essential activities like work and grocery shopping and discretionary activities like leisure activities.

Table 6. Accessibility indicators for New Mobility services

Indicator 4.1: Access latency	
Policy mandate	Promote an efficient and sustainable transport system.
Policy action	Plan the deployment of additional New Mobility services or regulate rebalancing, charging and maintenance activities to ensure convenient and timely access for all potential users.
Considerations	The term "latency" is used for this indicator to represent access time across all New Mobility modes. This indicator enables comparison across all New Mobility modes, including car-based and micromobility modes.
Reporting frequency	Monthly or annually
Data needs	1. Average waiting time between request and pick-up (i.e. latency) for ridesourcing and ridesharing services each hour (aggregated to predefined geographic zones). 2. Average time to access the nearest available vehicle (i.e. latency) for vehicle-sharing services each hour (aggregated to pre-defined geographic zones). 3. Percentage of unfulfilled trips (number of route or vehicle searches divided by the number of trips undertaken).
Calculation method	<u>Average access latency</u>: take the average time to access a New Mobility service at key policy-relevant time periods, such as the morning peak, mid-day, afternoon peak and evening.
Examples in practice	Chicago, Illinois, in the United States, used access time as an indicator to evaluate a new e-scooter vehicle-sharing service (City of Chicago, 2021) and passenger wait time to evaluate ride-hailing (CMAP, 2019).
Indicator 4.2: Number of trips starting or ending near essential services and opportunities	
Policy mandate	Ensure broad access to opportunities across the region.
Policy action	Plan the deployment of additional New Mobility services or introduce new infrastructure, such as mobility hubs, to facilitate the use of New Mobility to pursue essential activities. Using public transport hubs as key destinations may offer insight into whether New Mobility modes complement or compete with public transport.
Considerations	This indicator can be used to compare travel behaviour across all New Mobility modes. Geographic zones should be large enough to mitigate privacy concerns (e.g. larger than a single address or building) but not so large as to prevent detailed policy analysis. This indicator only provides a first-order estimate, as true trip origins and destinations cannot be determined for most New Mobility modes.
Reporting frequency	Monthly or annually
Data needs	1. Location where trip starts (aggregated to pre-defined geographic zones).

	2. Location where trip ends (aggregated to pre-defined geographic zones). 3. Locations of essential services and opportunities.
Calculation method	Number of trips starting or ending near essential services and opportunities: sum the number of trips beginning and ending in each zone. Identify zones that contain or are within a distance threshold of each key destination. Suggested key destinations include public transport hubs, healthcare facilities, job centres and grocery stores.
Examples in practice	Montreal, Canada used the percentage of trips starting or ending at a public transport station to evaluate an e-scooter pilot in 2019 (Lau, 2020).
Indicator 4.3: Vehicle or trip availability by area (spatially aggregated)	
Policy mandate	Ensure broad access to opportunities across the region.
Policy action	Plan the deployment of additional New Mobility services or regulate rebalancing, charging and maintenance activities to ensure that New Mobility is consistently available in designated areas.
Considerations	This indicator can be used to compare availability across all New Mobility modes. Geographic zones should be large enough to mitigate privacy concerns (e.g. larger than a single address or building) but not so large as to prevent detailed policy analysis. Whether a vehicle is in "good working condition" may be subjective, and not all issues are immediately known to the operator, so this indicator may slightly overestimate true availability.
Reporting frequency	Monthly
Data needs	1. Number of available vehicles in good working condition or available capacity each hour, aggregated to pre-defined geographic zones.
Calculation method	Average number of vehicles or trips available: take the average number of vehicles or capacity available in each zone across the hours of the day and then across the days of the month.
Examples in practice	The US city of San Francisco, California uses carsharing availability by geographic area to evaluate an early pilot programme and inform future policy decisions (SFMTA, 2017).
Indicator 4.4: Trip purpose	
Policy mandate	Ensure broad access to opportunities across the region.
Policy action	Identify opportunities to make essential trips more convenient through improved infrastructure, increased availability of New Mobility modes, or even land-use reform.
Considerations	This indicator can be used to compare the trip purpose distribution of all New Mobility modes, including private users of New Mobility vehicles (depending on the survey design). Traditional surveys are often expensive to conduct but could potentially be administered through a New Mobility platform's application interface for those services delivered via an application.
Reporting frequency	Annually or at regular multi-year intervals
Data needs	1. Survey responses from a representative and statistically significant sample of New Mobility users. Suggested trip purpose options include grocery shopping, family care, education, work, leisure, socialising and healthcare.
Calculation method	Trip purpose: count the total number of trips for each purpose, with responses weighted to provide a representative sample of New Mobility users.
Examples in practice	The US city Los Angeles, California uses survey questions about trip purposes to understand the impacts of bikesharing platforms on overall accessibility (SCAG, 2019).

Equity indicators

New Mobility can be a major asset in meeting transport equity objectives, but only if performance is measured and analysed carefully. New Mobility services can connect areas with limited public transport access to the rest of the city. New Mobility can also offer convenient door-to-door services for people with physical disabilities, given the right policies and regulations.

The indicators below represent physical measures of equitability (access, number of trips, availability of certain types of services). Two of the indicators focus on measuring New Mobility performance in "targeted service areas", which should be defined by local governments based on their equity goals. These areas might include neighbourhoods with limited public transport service, lower-income communities, or environmental justice zones, where more than 20% of the population lives below the federal poverty line or more than 30% identifies as a non-white minority. Indicator 5.1 relates to vehicle or trip availability in targeted service areas, which New Mobility operators can directly influence. Indicator 5.2 relates to trips starting or ending in targeted service areas that are indirectly influenced by New Mobility operators but are more relevant to policy makers with a mandate to improve mobility equity.

Economic aspects of equitability are also important to consider – and first among these are affordability indicators. These are not included below but should be addressed in further work on the topic. Such affordability indicators should be normalised to costs-per-kilometre (accounting for some proxy to measure surge pricing for those modes using that technique). They could also be presented in a way that captures the cost of these services compared to other transport modes or (where underlying passenger kilometre travel data is available) as a percentage of average household transport or total expenditures.

Table 7. Equity indicators for New Mobility services

Indicator 5.1: Vehicle or trip availability in targeted service areas	
Policy mandate	Share the benefits of New Mobility with all residents.
Policy action	Plan the deployment of additional New Mobility services or regulate rebalancing, charging and maintenance activities to ensure that New Mobility modes provide equitable access to services.
Considerations	This indicator can be used to compare availability across all New Mobility modes. Targeted service areas should be defined by local governments based on equity goals.
Reporting frequency	Monthly or annually
Data needs	1. Number of vehicles available (and in good working condition) or trips available each hour, aggregated to pre-defined geographic zones. 2. Geographic boundaries representing targeted service areas.
Calculation method	<u>Average vehicle or trip availability in targeted service areas</u>: take the average number of vehicles or trips available in each zone across hours of the day and then across days of the month. Determine the average and range of vehicle or trip availability for geographic areas in targeted service areas. <u>Vehicle or trip availability in targeted service areas relative to broader service area</u>: compare the results above against results for the full-service area.
Examples in practice	The US city Seattle, Washington requires micromobility operators to allocate 10% of their fleet to designated equity focused-areas (Beekman, 2020).

Indicator 5.2: Number of trips starting or ending in targeted service areas	
Policy mandate	Share the benefits of New Mobility with all residents.
Policy action	Incentivise higher vehicle and trip densities in targeted service areas to promote utilisation. Adapt regulations to support the latter. Launch community engagement initiatives to boost awareness. Explore subsidies to make New Mobility affordable to lower-income households.
Considerations	This indicator can be used to compare availability across all New Mobility modes. Targeted service areas should be defined by local governments based on equity goals. Geographic zones should be large enough to mitigate privacy concerns (e.g. larger than a single address or building) but not so large as to prevent detailed policy analysis.
Reporting frequency	Monthly or annually
Data needs	1. Location where trip starts (aggregated to pre-defined geographic zones). 2. Location where trip ends (aggregated to pre-defined geographic zones). 3. Geographic boundaries representing targeted service areas.
Calculation method	Number of trips starting or ending in targeted service areas: sum the number of trips beginning and ending in each zone that is within a community of concern. Number of trips starting or ending in targeted service areas relative to broader service area: compare the results above against results for the full-service area.
Examples in practice	Los Angeles, California, in the United States, measures the percentage of micromobility rides originating in disadvantaged communities (LADOT, 2020).

Indicator 5.3: Vehicle and trip availability for users with physical disabilities	
Policy mandate	Share the benefits of New Mobility with all residents.
Policy action	Incentivise or regulate increasing shares of accessible vehicles in New Mobility fleets.
Considerations	These indicators are specifically intended to enable comparison across all New Mobility modes, including car-based modes and micromobility modes. The physical disabilities of concern should be defined by local governments based on equity goals.
Reporting frequency	Monthly or annually
Data needs	1. Total number of vehicles available for vehicle sharing or ridesourcing during the analysis period. 2. Description of vehicle types and their level of accessibility for different physical disabilities. 3. Latency between accessible vehicle request and trip start.
Calculation method	Accessible vehicle and trip availability: take the number of accessible vehicles available for each physical disability of concern and divide it by the total fleet size. Waiting time indicator for accessible services: average of all accessible vehicle latency durations compared to all vehicle access latencies.
Examples in practice	The US state of California requires ride-hailing companies to make wheelchair-accessible vehicles available within a specified response time for each region (Venkataram and D'Agostino, 2022).

Potential performance management challenges

Establishing a New Mobility performance management programme or adapting an existing one for a new mode or service requires significant effort and collaboration. Regulators may face legislative, technical and data reporting challenges.

The first challenge lies in determining the correct legislative authority. Public authorities at the local level may not have the legal authority to grant or withhold operating licenses for New Mobility services or to require data reporting as a condition for receiving a license. Local governments should work with regional or national counterparts to ensure they have a role in shaping and executing the legal framework for regulating New Mobility. Guidelines for developing the regulatory framework for New Mobility services can be found in the ITF's *Regulating App-based Mobility Services* report (ITF, 2019).

Allocating the necessary resources to maintain a comprehensive New Mobility performance management programme is another major challenge for all levels of government. Proactive regulation and policy making for New Mobility services require a complementary but distinct set of competencies for most transport authorities. Trained staff and software tools are needed to prepare the performance indicators and generate actionable policy insights. Governments may find that third-party consultants or service operators themselves could complement public expertise when setting up a performance management programme. However, even if tasks are outsourced to third parties or service operators, public authorities must have sufficiently knowledgeable staff who understand and can manage those relationships and evaluate the quality of the inputs. At a minimum, public authorities should require all staff responsible for overseeing New Mobility services to have the necessary digital and data skills. A recent OECD concept note, *Competition and Regulation in the Provision of Local Transportation Services* (OECD, 2022), provides several examples of innovation by public authorities in New Mobility regulation.

Finally, a well-designed and efficient data reporting framework is essential for New Mobility performance management. Performance indicators cannot be elaborated or used for policy development without access to the underlying data and the ability to verify data if needed. The next section discusses data reporting for New Mobility in detail.

Collecting data for New Mobility performance indicators

The New Mobility performance indicators presented in the previous section require the appropriate data. Acquiring those data can be challenging for public authorities. Until now, national statistical offices and public authorities have used traditional data collection methods to measure passenger mobility: household travel surveys for walking and cycling, vehicle counts and odometer readings for road motor vehicles, ticketing counts for rail transport. At the same time, much of the data collection and monitoring of New Mobility services has occurred at the local and regional levels. Aggregated data are rarely passed upwards to national authorities for use in international comparison.

The need for a data governance framework is becoming increasingly evident to 1) facilitate data reporting from the private sector, which owns the majority of the data, to the public sector and 2) co-ordinate data collection across multiple levels of government (ITF, 2021b). New Mobility services generate a significant amount of digital data. Public authorities can use the data to monitor and guide the development of New Mobility services in line with public policy objectives. However, these data usually remain with the private-sector actors that collect or generate them. Public data governance would help reconcile what is technically possible, what is desirable and what is legally permitted.

This section focuses on data held by mobility operators. Therefore, it will not include data already available from other sources. For example, the number of injuries and injury crashes used to calculate safety indicators 2.1 and 2.2 are collected by the police and hospitals, and thus will not be mentioned below. In addition, this report focuses on data reporting, not data sharing. Data sharing refers to data shared among different stakeholders to enable mobility services (ITF, 2021b). Data reporting refers to data reported by mobility operators to public authorities, enabling the latter to monitor outcomes and guide policy (ITF, 2021b).

Approaches to reporting New Mobility data

There are three main approaches for New Mobility service providers to report New Mobility data to public authorities. The first is that public authorities request raw data related to a private company's service and decide which indicators to measure based on those data. However, this approach is inefficient due to the wide range of indicators, and the risk of calculating indicators that are difficult to interpret or explain to the public. Furthermore, operators typically employ bespoke data structures and syntaxes. Public authorities must analyse data provided on a case-by-case basis or invest in transforming the data into a common syntax. Analysing these data requires specific knowledge that public entities often do not have in-house. In addition, storing and maintaining large amounts of raw data is costly and risky in terms of potential data breaches.

The second approach is for public authorities to define and articulate policy objectives and related indicators. They should also provide a means of measuring progress towards those objectives (e.g. those suggested in the list of indicators in the previous section). On that basis, public authorities can request either the indicators themselves or the data necessary for calculating those indicators from the operator.

Adopting this approach would be beneficial for both data providers and data receivers. Data providers relay only the data necessary to calculate the indicator, most of the time at an aggregate level. This helps make data reporting compatible with privacy concerns. For example, for indicator 4.2 Number of trips starting or ending near key destinations, public authorities adopting the first approach would ask for all the data, including location data, which would create issues with privacy regulations, especially in the European Union. Conversely, if the second approach were adopted, mobility operators would aggregate the raw data and provide only the total number of trips starting or ending near key destinations (ITF, 2021c). Another advantage is that data producers can offer the same type of data, using the same analysis technique, to different public authorities, thus achieving economies of scale. Public authorities would benefit from receiving clean and ready-to-use data, minimising data validation and processing costs. However, under this model, public authorities must trust the private sector to provide reliable and accurate data. Formal data quality and accuracy audit mechanisms must be in place to anchor that trust.

The third approach is for public authorities to assign the task of collecting and analysing data to third-party data processors. In this case, public authorities should inform operators of how their data will be used and assure them that they will not be used for purposes outside of the agreed terms.

This approach has advantages for public authorities and mobility operators alike. Many public authorities do not have the in-house capacity to process data and often outsource the task to third-party aggregators. For mobility operators, reporting data using the second approach can be burdensome, especially if different public authorities do not co-ordinate their requests. Providing raw data directly to third-party aggregators would reduce mobility operators' time preparing the data. However, public authorities will need to compare the cost of hiring a third-party aggregator to that of hiring qualified new staff or training existing staff. Public authorities must also avail themselves of data audit and vetting processes for data delivered by mobility operators and data provided by third-party processors. Adding third-party processors in the mix may increase economies of scale if these interact with many mobility operators and authorities and may also give rise to innovations in measuring and monitoring trends.

Data collected or generated by the private sector pose two policy-relevant risks: privacy and commercial sensitivity. Privacy is related to personal data. According to the OECD, personal data refer to "any information relating to an identified or identifiable individual (data subject)" (OECD, 2013). This definition is extended in Article 4.1 of the EU's GDPR as:

> …any information relating to an identified or identifiable natural person ("data subject"); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number [e.g. social security number], location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity [e.g. name and first name, date of birth, biometrics data, fingerprints, DNA …] of the natural person. (EU, 2016)

Both identification and re-identification – that is, the ability to isolate an individual from anonymised or pseudonymised – are personal privacy risks. In this context, location data are potential indirect identifiers of individuals and their behaviour. For this reason, personal data should be de-identified through privacy-preserving mechanisms (PPMs). Cunha, Mendes and Vilela (2021) provide a helpful taxonomy for selecting appropriate data de-identification PPMs (see Box 1).

Box 1. Privacy-preserving mechanisms for data reporting

The ability to associate data with the identity and behaviour of a specific person represents a serious challenge to privacy rights. Data stripped of direct and indirect identifiers may still be used to re-identify natural persons. Re-identification techniques are generally not trivial, but many are not difficult to apply successfully. In light of these risks, multiple forms of privacy-preserving mechanisms (PPMs) have been developed and applied. Privacy-preserving strategies must account for the data type (structured, semi-structured and unstructured) and the data sub-type (text, numerical, streaming, geospatial, etc.). Generally, however, PPMs employ one, or a combination, of three broad approaches:

- anonymity-based approaches, which strip identifiers and group records into sufficiently indistinguishable sets
- obfuscation-based approaches, which introduce spurious records, synthetic records and data or generalise specific data (e.g. location data) to thwart re-identification
- cryptographic-based approaches, which employ computational cryptography and permissioned data record access to protect data.

Public authorities seeking to ensure personal data protection should assess if, when and what type of PPM to apply to any personal data they receive or collect. Taxonomies of data types and appropriate PPMs are integral to the personal data protection task. They should be updated and re-assessed as PPM efficacy evolves and re-identification threats grow more sophisticated.

Source: Cunha, Mendes and Vilela (2021).

The second type of risk relates to commercially sensitive data. Private companies are reluctant to report data that disclose sensitive information about their activities and business models. This information can prejudice the company’s competitive position. The onward transfer of potentially commercially sensitive data from mobility operators to authorities should be accompanied by a degree of trust that public authorities will be good stewards of that data and will implement sufficient protections against data breaches. As with any onward data transfer from mobility operators, the third-party processor model does not prevent the risk of data breaches. The ITF report *Reporting Mobility Data: Good Governance Principles and Practices* (ITF, 2021b) recommends data reporting and handling protocols that mitigate these risks.

Data reporting: New Mobility data formats

The second aspect to consider for data reporting is data structure and format. Without a convergence towards compatible data structures and syntaxes, data reporting requirements can be burdensome or costly for private companies. Most operate in different cities, regions and countries and must report data to several public authorities. Likewise, public authorities risk receiving data in incompatible formats when requesting data from several service providers. A common understanding of terms (semantics), data structure (schemas) and data reporting with specific machine-encodable and readable formats (syntaxes) enables straightforward and efficient data reporting. This can help public authorities carry out their mandates and analyse the data received from different companies operating in the same jurisdiction. It can also serve as the basis for upwards compatible and cross-jurisdiction comparable data.

Data semantics

Traditional transport services, such as public transport, already have accepted semantic models. On the contrary, most New Mobility services still do not have one. The first section of this report provided a taxonomy of current services and vehicles. It can be a future reference to help build the data semantics for incorporating New Mobility services.

There are other examples of initiatives that provide a common language to describe New Mobility vehicles, services and operations. The first one is the Open Standards for Linked Organisations (OSLO) semantical model, developed in the Flanders region of Belgium. It established a lexicon referring to traveller and trip information, booking actions, network descriptions, operators' service supplies and operating licences (OSLO, n.d.). SAE provides a standardised set of definitions and methodologies covering commonly used terms and indicators in several publications: Mobility Data Collaborative Data Sharing Glossary and Metrics for Shared Micromobility (MDC, 2022), Taxonomy of On-Demand and Shared Mobility: Ground, Aviation and Marine – JA 3163 (SAE, 2021) and "Taxonomy of Powered Micromobility Vehicles – JA 3194" (SAE, 2019). The Mobility Data Specification (MDS) comprises a "metrics" application programming interface (protocols that allow data to flow securely between operators and authorities, API) endpoint which generates indicators from MDS data, incorporating common semantical terms underlying their calculation (OMF, 2020). Finally, the EU Public Transport Reference Data Model (EN 12896) or "Transmodel" includes a well-documented glossary of mobility services and terms (CEN, n.d.).

Data schemas

A common understanding of semantical terms (or a common and consistent translation logic between different terms) is a necessary pre-condition for data reporting and sharing. However, it seems a far reach to envisage a common data syntax for all mobility services, or even all New Mobility services. Though it is theoretically possible to describe operations for e-scooter-sharing and a subway using the same syntaxical model, it is not easy or practical. This level of syntaxical convergence would also prove costly and burdensome, as it would require service operators to adapt their systems. In addition, adopting a single data syntax (or locking one syntax in for each type of mobility service) can potentially hamper innovation.

A preferable approach is encouraging convergence around functional data structures or schemas and letting actors adopt syntaxes within those common structures. This ensures that each discrete data syntax can be mapped to another, facilitating data collection and processing (ITF, 2021d).

The EU Transmodel is a well-known example of a data schema. It provides a consistent language that covers many aspects of public transport. It has been developed and enhanced over several decades by public transport experts from European countries (CEN, n.d.). In the latest version of Transmodel, additional concepts were added to simplify bridging traditional public transport and alternative modes, such as cycling and carsharing.

Data syntaxes

Mobility data syntaxes structure data and enable their processing in a consistent and coherent manner. Currently, no universal data reporting standard has been adopted, but there is a benefit in converging towards a limited set of open and mode-neutral syntaxes. This convergence can reduce burdens for both data providers and data receivers. However, they may create additional risks concerning personal or commercially sensitive data due to the detail and granularity of the data collected. For this reason, the data syntaxes should include personal data protection by default and design to minimise the risks of collecting and storing commercially sensitive data.

Different data syntaxes already exist and may become a standard in the future. Examples of these are Network and Timetable Exchange (NeTEx), General Bikeshare Feed Specification (GBFS) and the Mobility Data Specifications (MDS).

NeTEx is a standard developed by the European Committee for Standardisation (CEN) for exchanging public transport schedules and related data (network, timetable and fare information). Many NeTEx concepts are taken directly from Transmodel. The definitions and explanations of these concepts are extracted directly from the respective standard and reused in NeTEx, sometimes with adaptions to fit the NeTEx context. Data in NeTEx format are encoded as XML documents that must conform precisely to the Transmodel schema. In 2017, the EU Commission Delegated Regulation (EU) 2017/1926 recommended developing a data exchange format dedicated to new modes (EU, 2017). This work resulted in NeTEx Part 5, which describes carsharing, cycle-sharing, carpooling, car and cycle rental and other services and their inclusion in the Service Interface for Real Time Information, or SIRI (CEN, 2020). While the NeTEx format does not create privacy issues in public transport data, it may risk re-identifying unique users. Therefore, there should be a system to de-identify personal data.

The General Bikeshare Feed Specification (GBFS) is an open standard that defines shared mobility services. It has supported the recent integration of various shared mobility services in trip planning applications. It was created by Mitch Vars and endorsed by the North American Bikeshare Association (NABSA) in 2015 before the transfer of its maintainership to MobilityData in 2022. It is now used in hundreds of cities across at least 45 countries (MobilityData, 2020). Trip planning and Mobility as a Service (MaaS) applications use these data to help travellers in choosing shared mobility, integrating public transport into the offer. In addition, GBFS facilitates public authorities' analysis and comparison of data generated by shared mobility systems (MobilityData, 2021). In 2020, GBFS version 2.0 was launched to meet new needs, especially concerning the protection of personal data. For example, the latest version recommends rotating the unique IDs of a vehicle once it has finished a trip to prevent the reconstruction of a trip made by a single, potentially identifiable rider.

The Mobility Data Specification (MDS) is a set of APIs that helps public authorities manage transport better. It standardises communication and data-sharing between mobility operators and public authorities. Through it, authorities can share and validate policy digitally, facilitating vehicle management and better outcomes for the population. In addition, it provides mobility service operators with a framework they can use in new markets. (OMF, n.d.1)

MDS was initially developed for the City of Los Angeles, California in the United States. It is managed by the Open Mobility Foundation (OMF). MDS's initial purpose was to help cities monitor and manage micromobility services. Cities have called for expanding the scope of MDS. The release of MDS version 2.0.0 will cover additional mobility services – including ridesourcing and taxis (OMF, n.d.2).

At its core, MDS is a set of APIs (OMF, n.d.3). As described in Box 2, there are three primary sets of APIs (agency, provider and policy) and three additional ones (geography, jurisdiction and metrics).

MDS is a very promising tool. However, there are concerns about the detail and granularity of the data collected by the initial formulation of some APIs. As a result, OMF issued a privacy guide to help authorities implement MDS, although it primarily focused on the US context (OMF, 2020). In December 2021, OMF also released detailed guidance on using MDS in the context of the GDPR in Europe (OMF, n.d.4). MDS now includes a "policy requirements" endpoint in the Policy API that enables public authorities to specify exactly which data they require and at what level of aggregation to meet their data privacy concerns (OMF, n.d.5).

Box 2. Mobility Data Specification application programming interfaces

The Mobility Data Specification (MDS) uses application programming interfaces (APIs). APIs are protocols that allow data to flow securely between operators and authorities. MDS offers three primary sets of APIs:

- Agency API: enables mobility service operators to push real-time data to a database managed and housed by the public authority (or a designated third party). It enables real-time data collection and supports real-time analysis and adaptive regulation. It is implemented by regulatory agencies.
- Provider API: is designed to enable public authorities to pull historical or real-time data from the mobility service operator. It allows authorities to directly manage their reporting flows from operators and potentially reduce their data storage requirements. It is implemented by mobility service providers.
- Policy API: allows regulatory agencies to publish geography-based regulations and service providers to adjust their offers as policies change. It reduces the burdens of regulatory agencies by removing the need to communicate changes manually to providers. It is implemented by regulatory agencies.

Three additional APIs support the core MDS APIs:

- Geography API: looks at spatial coverage and boundaries that define where the rules set out in the Policy API apply or that trigger data logging and reporting in the Agency, Provider and Metrics APIs.
- Jurisdiction API: is used to define and communicate hierarchical or overlapping administrative or operational areas associated with specific data access rights.
- Metrics API: establishes common methodologies for creating indicators from MDS data. This API defines common indicator semantics and ensures that indicators are consistently being calculated.

Source: OMF (n.d.3).

Public authorities and mobility operators should co-operate to define standardised data formats that enable data reporting efficiencies in line with the need to monitor and guide policy. Convergence towards standards is most important with each type of New Mobility service. In contrast, convergence around a set of standards covering all mobility services – including new ones – is a longer-term goal.

Public-private agreements for reporting New Mobility data

The last aspect to consider for data reporting is which public-private agreement is best suited for private companies reporting New Mobility data to public authorities. There are different possibilities that public authorities can apply. ITF (2016) identified five main models of data reporting: 1) public-private data partnerships; 2) public-citizen data partnerships; 3) mandatory data sharing; 4) new data-sharing model; and 5) open data. Based on this, the European Investment Bank (EIB) elaborated seven ways for reporting data: 1) public procurement of data; 2) intermediaries; 3) financially compensated partnerships between the public and private sectors; 4) in-kind partnerships between the public and private sectors; 5) mandatory data sharing; 6) collaboration between authorities; and 7) crowdsourcing (EIB, 2021). In addition, ITF (2021b) pinpointed four over-arching data acquisition models for gathering data generated by private companies and needed by public authorities (see Box 3).

Box 3. Data acquisition methods

In the report *Reporting Mobility Data: Good Governance Principles and Practices*, the International Transport Forum identified four data acquisition models:

- Compulsion: The act of requiring or compelling the transfer of data from an individual or a firm to a public authority is the strongest and most constraining method by which a public authority may acquire data. This approach is generally deployed when the social benefits of acquiring data from individuals or firms outweigh individual privacy or commercial sensitivities linked to those data remaining out of government hands. Public authorities must ensure that personal or sensitive data are not released or used in ways not aligned with public policy objectives, including protecting individual privacy and commercial competitiveness.
- Conditionality: The act of requiring the transfer of data in order to access a service, a set of rights, or a licence to operate is also a common data acquisition pathway for public authorities. It is common in the transport sector to require an exchange of data in order to access an outcome. This allows the public authority to monitor the conditions in which the outcome is delivered (driver licencing, delivery of public transport contracts and granting mobility service licences to operate).
- Co-operation: The act of firms or individuals volunteering data to public authorities in order to obtain mutually beneficial outcomes is a less common data-acquisition pathway for public authorities. Firms may wish to share data with public authorities via voluntary agreements as a way of building trust and avoiding more constraining data-reporting requirements.
- Commercial terms: Governments may also acquire data by purchasing it from data aggregators and processors. These data are typically obtained by private firms from a number of sources and may include personal or sensitive data in its raw form. The data are aggregated, anonymised and processed to meet particular public authorities' needs for which governments are willing to pay.

Source: ITF (2021b).

Identifying one single best agreement under which private companies report data to public authorities is difficult. Therefore, public authorities should choose the most appropriate agreement to request the data based on their adopted indicators.

Public authorities should require compulsory reporting of all data necessary for priority indicators. For example, a study conducted in 13 cities showed that the majority required the submission of trip data to monitor and control the industry's growth, improve safety, increase access, understand drivers' working conditions and effectively track the use of their public streets (Holm Møller and Simlett, 2020).

Another viable option for measuring the prioritised indicators is to make the data reporting a condition for receiving the licence to operate in a jurisdiction. In 2019, Los Angeles, California, in the United States, launched the Dockless Vehicle Pilot Program to regulate dockless modes (LADOT, 2020). There were concerns about public safety, accessibility, and right-of-way management linked to New Mobility services. Among the requirements needed to apply to the programme, private companies had to maintain MDS compliance and submit quarterly reports on usage rates of equity service options.

Public authorities can also decide to co-operate with the private sector. The city of Paris' early engagement with micromobility operators was an example of this type of co-operation. In 2019, the city established a working group for all e-scooter stakeholders, inviting e-scooter operators to sign a Code of Good Conduct. The Code provided a guiding principle for operating in the city and included a data-sharing section (Figg, 2022). Thereafter, however, the city choose a public tender-based model to select three operators. Under the terms of the tender, data reporting to the city became compulsory for the selected operators.

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