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WORKING PAPER

DEMAND RESPONSIVE TRANSIT: UNDERSTANDING EMERGING SOLUTIONS

GERMAN FREIBERG, LEONARDO BUENO, BRUNA PIZZOL, DAVID ESCALANTE, AND TANIA PÉREZ

EXECUTIVE SUMMARY

- Demand Responsive Transit (DRT) adapts well to users' needs and can increase efficiency in situations where regular public transport systems are more costly (areas of low population density and low demand). However, as DRT modes are constantly evolving, the concept and its applications and benefits can be hard to grasp.
- This working paper is aimed at decision-makers, mobility analysts, and planners who wish to understand this emerging type of service. It provides an introductory description, including a proposed classification of DRT service types, an overview of institutional aspects and key operational attributes, and examples of DRT implementation around the world.
- This study identifies a trend in which high-income countries' implementation of DRTs has resulted from defined public planning policies, DRTs are integrated with the regular public transport networks, and subject to government regulation.
- In developing countries, DRTs arise mostly from private sector initiatives aimed at market demand niches where regular transit is not sufficiently attractive, or where people with a higher willingness to pay are not necessarily included in city and transportation authority planning efforts.

CONTENTS

Working Papers contain preliminary research, analysis, findings, and recommendations. They are circulated to stimulate timely discussion and critical feedback, and to influence ongoing debate on emerging issues.

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Box 1 | **Key Findings from the Working Paper**

We propose two elements that help identify common characteristics of DRT cases:

- How DRT services relate to and interact with regular public transportation operating in the same city/region.
- Whether DRT services are created through public policy or privately to serve a market (Enoch et al. 2004).

When DRT schemes are conceived in a top-down approach, as a public policy, it is more likely that they will be integrated with the regular transportation network from the start. This finding is in line with the insights of Mulley et al. (2012).

In high-income countries, the predominant models of general public DRT services derive mostly from public policies that have been defined, planned, and regulated by the government.

In developing countries, general public DRTs appear more as private services aimed at market demand niches that are not properly addressed by regular public transport. Demand comes either from people who live in areas outside public transit routes or from people with a higher willingness to pay for more flexible or direct service. In the latter case, DRT services must compete with a range of transport options: from regular public transportation, to ride-hailing or private charter buses and cars. Table ES-1 compares the two models.

Source: Authors.

Background

Demand responsive transit systems offer options for shared mobility. They vary widely in their operational, functional, technological, economical, and institutional characteristics. They can offer route flexibility, solutions for people with reduced mobility, and real-time information to users. They can serve low population density areas, connect to remote areas, and—in areas where public transit is non-existent—they can offer transport services more efficiently than traditional transit systems.

Previous studies of DRT systems are limited in number and usually focus on a specific location and/or aspect. We believe that by considering a wider range of information and updating earlier studies, this paper may improve planning and decision-making and will help planners to advance research on the subject. We are aware that this paper does not cover important dimensions of analysis such as costs and financing, demographics of users served, urban and social implications, and some dimensions related to service providers. The paper should be seen as an exploratory study to characterize a fast-growing and diverse mode of transportation. A further limitation is that, while we intended to study cases across a broad geographical distribution, we were unable to access sufficient Asian examples due to language barriers.

Table ES-1 | **Summary of common characteristics of private market services versus public policy-derived DRT schemes**

PRIVATE COMPANY INITIATIVES AIMED AT MARKET DEMAND NICHES	SYSTEMS CREATED BY PUBLIC POLICIES
Private companies create DRT services to serve market niches that are poorly served by regular public transport (among other modes).	Systems generally planned as part of the regular transit systems, in most cases as feeders. Typically, a government decision. DRT service may be outsourced to private companies or planned and operated by the government itself.
Characteristic most associated with competitors: competition with ride-hailing users as well as regular public transportation users.	Characteristic most associated with supplementary and substitute services: advantageous use of technology to improve public transportation.
Typically, no fare integration.	Typically has fare integration (or is offered by government at no charge).
Predominant in developing countries.	Concentrated in developed countries.
Examples: Shuttl, CityFlo (India), Jetty, Urbvan, Bussi (Mexico), CityBus 2.0, TobBus+ (Brazil), Uber Bus (Egypt).	Examples: TAD IDMF, FlexHop, Résa'Tao (France), Bridj, Keoride (Australia), LA On Demand Pilot, Arlington, King County, West Sacramento (USA).

Source: Authors.
Notes: Different combinations of these characteristics can be found in many DRT cases; this table shows tendencies found in the cases analyzed, not necessarily indicative of future implementations.

The literature uses various terms: demand-responsive transit, on-demand transit, bus on-demand, or microtransit. This study uses *Demand Responsive Transit*, or DRT, defined as **transportation services with some degree of demand-responsive route and/or schedule flexibility, operating with transit vehicles (vans, microbuses, and buses) and IT-based user access on a "as-needed" basis.**

This study focuses on DRT schemes that use vans, microbuses or buses that serve the general public (as opposed to private organizations or groups). It does not include ride-hailing schemes such as Uber or Lyft.

About this working paper

This paper addresses the question of how a variety of DRT service types and attributes can serve different transit demands and needs. It assesses DRT schemes' relationship with public transport authorities and systems.

To create this overview of DRTs and validate the definitions and concepts proposed, the team collected and systematized data and presented it in an organized way. We relied on various data collection formats (literature review, a survey, online data gathering and interviews) that allowed us to strengthen the three proposed dimensions of analysis. Throughout, we make reference to examples of implementation from around the world. Our methodology is presented in more detail in the appendices found at the end of this working paper.

This working paper was made possible by the generous support of the IDB LAB and Shell Foundation through WRI's innovation area Propulcity and the technical effort carried out by REDES Planejamento e Política Pública.

Understanding DRTs

As Volinski (2019) states, DRTs are the chameleon of public transportation and can take many forms in different environments. They offer flexibility and customization to meet a great variety of needs, from both the operators' and users' perspectives. We propose a classification comprising six DRT service types, a set of key attributes, and a cross-cutting set of institutional dimensions (Table ES-2).

Table ES-2 | **Schematic summary of DRT service types, key attributes, and institutional dimensions**

DRT SERVICE TYPES	
Paratransit	Specific Destinations
Corporate/ University	Night Service
Intercity/Inter-region	General Public

DRT ATTRIBUTES	
Route Flexibility	Request method
Geographic Coverage	Payment methods
Vehicle type	Pricing

INSTITUTIONAL DIMENSIONS
Institutional arrangements
Integration with public transportation
Regulation

Source: Authors.

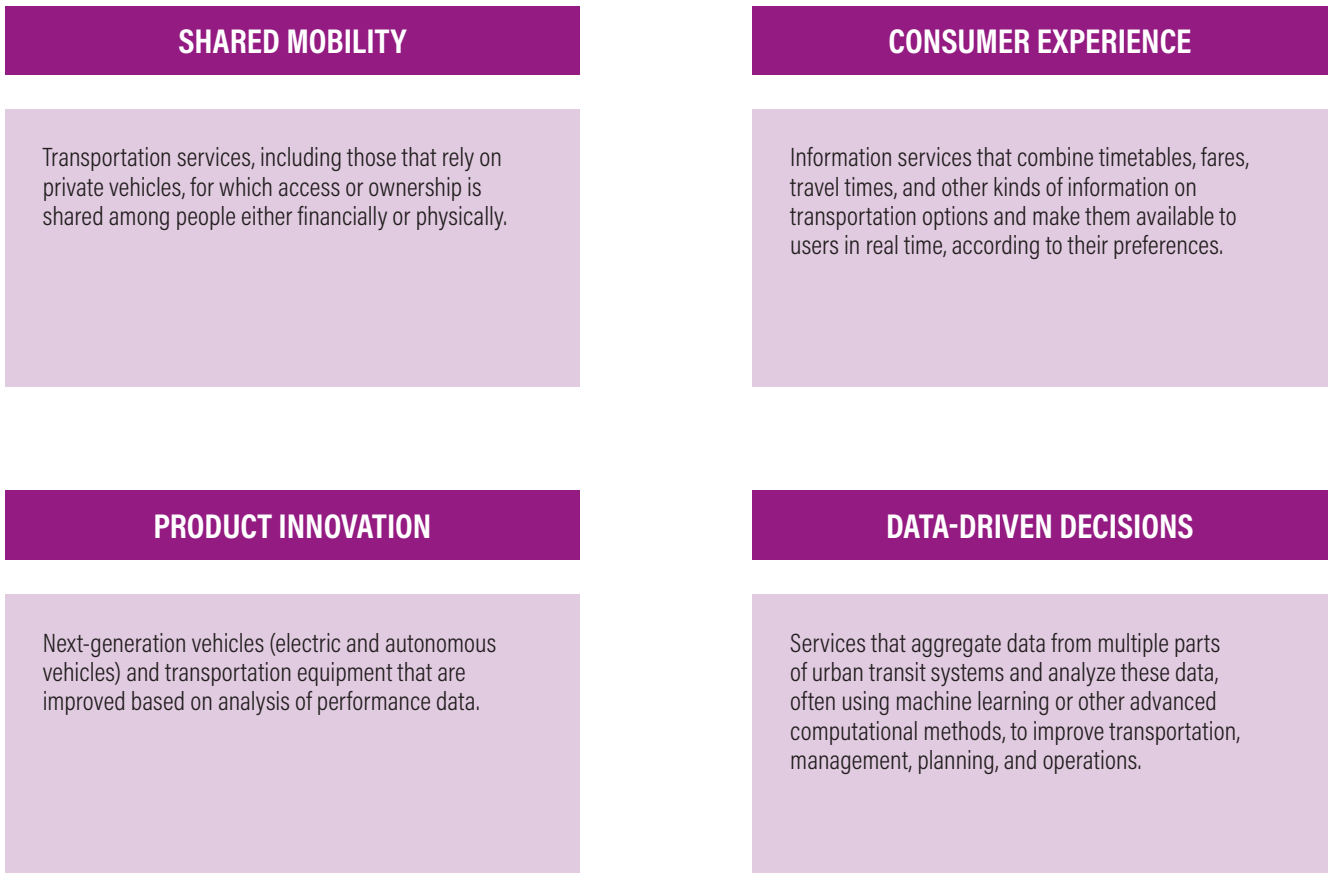
1. INTRODUCTION

Demand-responsive transit services have existed since the 1970s. Then, services were supported by phone calls and radio control (Alexander 1977). However, DRTs were largely limited to paratransit systems (e.g., services for people with disabilities) or in rural or low population-density areas, where fixed line routes are more costly. Until recently, passenger transportation was dominated by cars and conventional transit systems such as subways, trains, and fixed route bus networks, and there was little room for other transport modes. Taxis have always been in the mix, but on-demand transit options have been modest.

"New mobility" encompasses a broad set of operating models and technologies (see Figure 1), that provide transportation to people, usually without requiring them to own private vehicles. Some of the most talked-about features of new mobility services are on-demand accessibility, mobile data connectivity, automation, and reliance on low- or zero-carbon energy sources (Canales et al. 2017). IT-enabled DRTs are part of a set of shared mobility concepts, but it is important to understand them as one element among many in the evolving phenomenon.

One segment of the shared mobility concept has been the dizzying growth of ride-hailing services (e.g., Uber) and

Figure 1 | **Characteristics of New Mobility Schemes**



Source: Connected Urban Growth: Public-Private Collaborations for Transforming Urban Mobility.

the large-scale rollout of dockless bikes and e-scooters. Ride-hailing services were initially quite disruptive in many cities, but they all followed similar models: "facilitator" companies provide an app to match supply and demand, but do not own the fleet vehicles or employ the drivers. Dockless bikes and e-scooters rolled out with more diversity of models and services, though these were largely indistinguishable to the user. All these services represent independent travel alternatives to other common mobility modes, like private vehicles, regular public transportation, or the traditional taxi.

By contrast, in recent years the DRT services present multiple types of service types, various degrees of integration with regular transit, and different institutional models, as well as widely varying flexibility regarding demand responsiveness. The term "demand responsive transit" thus encompasses a rather broad and heterogeneous group that requires a more specific and precise characterization if it is to be better understood.

Scope and Objectives of This Study

This study focuses on shared services operated in vans, microbuses or buses, because car-based services such as ride-hailing (although also on-demand) are closer to taxi services. Volinski (2019) states that, "DRTs are of great importance in that they are another available tool in the toolbox as mobility services try to provide the appropriate levels of supply to match the various levels of demand in their diverse service areas."

The following factors are among those fuelling the rise of demand-responsive services (Volinski 2019):

- Decreased ridership in transit services and growing popularity of ride-hailing services.
- The search for cost-effective services in low population-density areas or low-demand periods, while maintaining minimum frequency levels and quality of service.
- The search for services that enhance accessibility (eg. Paratransit) and equity (eg. extended coverage) in transportation.
- The growing interest of the private sector in supplying transportation services where fixed routes are not sufficiently attractive and serving people with a higher willingness to pay.
- The public's growing familiarity with on-demand services and their accompanying technology: ridesharing achieved through dynamic route-optimizing software and smartphone hardware that allow for easy-booking procedures, real-time information sharing to users, feedback mechanisms, and transparency on fares. Trip concerns such as estimated travel times and arrival times for both pick-up and drop-off, as well as personal safety issues, can also be addressed.

As DRTs continue to evolve, new developments will arise, and new questions emerge. Given the widely differing transportation needs in different locations, this study aims to understand **how the broad variety in both service types and operational attributes in DRT schemes have been adapted for different circumstances?**

The challenge is that systematic data about DRTs around the world are scarce. Publications exist specific to certain countries (predominantly developed countries) and/or focused on particular aspects of the systems, but there is little material with more comprehensive data on different DRT application types, or comparative studies of DRT in countries with different geographic, social, and economic contexts. Literature on DRTs in Latin America and in other regions in the global South is particularly lacking, though relevant publications can be found on India (Chadha, Shetty & Shastry 2018; Chadha & Shastry 2020).

The objective of this study is to propose a classification of DRT types, their attributes and see how these combinations have been implemented around the world, with the purpose of understanding how implementation proceeds in different contexts.

Section 2 of this paper provides definitions and an overview of DRT cases around the world (Dataset 1, Appendix C: based on a worldwide review of 151 cases). Section 3 provides a description of each DRT service type; based on dataset 2, Appendix F, comprising 32 cases of general public DRTs. Sections 4 and 5 describe institutional dimensions and the selected operational attributes respectively; each section and subsection present an illustrative case study. Section 6 presents key findings and final considerations Further information on this study's datasets and outputs can be found in the appendices.

2. DEMAND RESPONSIVE TRANSIT: A PANORAMA

DRT definitions

The following brief list of definitions shows that there no single or standardized definition of demand-responsive transit. Each author emphasizes different aspects, such as operational characteristics, or compares DRT with other modes of transport:

- "Demand-responsive transport is a user-oriented form of passenger transport characterized by flexible routes and smaller vehicles operating in shared-ride mode between pick-up and drop-off locations according to passengers' needs" (Institution of Mechanical Engineers, and Community Transport Association (CTA) 2018, 4).

- "Demand-response is a transit mode comprised of passenger cars, vans or small buses operating in response to calls from passengers or their agents to the transit operator, who then dispatches a vehicle to pick up the passengers and transport them to their destinations." (Federal Transit Administration (FTA) 2020).

- Intermediate form of transport between a bus and a taxi, which covers a wide range of transport services, from community transport to wider service networks (Grosso et al. 2002, cited in Enoch et al. 2004). Figure 2 depicts this idea.

Based on operational characteristics, we incorporate two additional definitional attributes for the present study:

- **Use of information technology:** Even though nearly all new services use IT, it makes sense to distinguish them from older phone scheduling systems. Phones are still the primary manner of accessing many paratransit services (transport services for people with disabilities), where demand responsiveness is rather limited. The use of big data on DRT does not just allow for real time route optimization, it is also increasingly used to identify travel patterns and demand behavior, which allows for flexible changes to planning and reorganizing supply. IT also allows users to track their trip, which provides greater safety and quality of service.

- **Use of transit vehicles, considering vans at minimum:** the aim of this attribute is to delineate DRTs and the ever-growing number of car-based shared mobility services (ride-hailing)[1], which fall outside the purview of this study.

For the purposes of this study, we define DRT as "transportation services with some degree of demand responsive route and/or schedule flexibility, operating with transit vehicles (vans, microbuses, and buses) and IT-based user access on an "as-needed" basis."

This definition along with the conclusions reached are not definitive, partly because they concern systems that are a combination of many factors and variables, and partly because DRTs are presently undergoing considerable transformation. Our analysis represents a snapshot that reveals insights into a rapidly changing process.

DRTs around the world

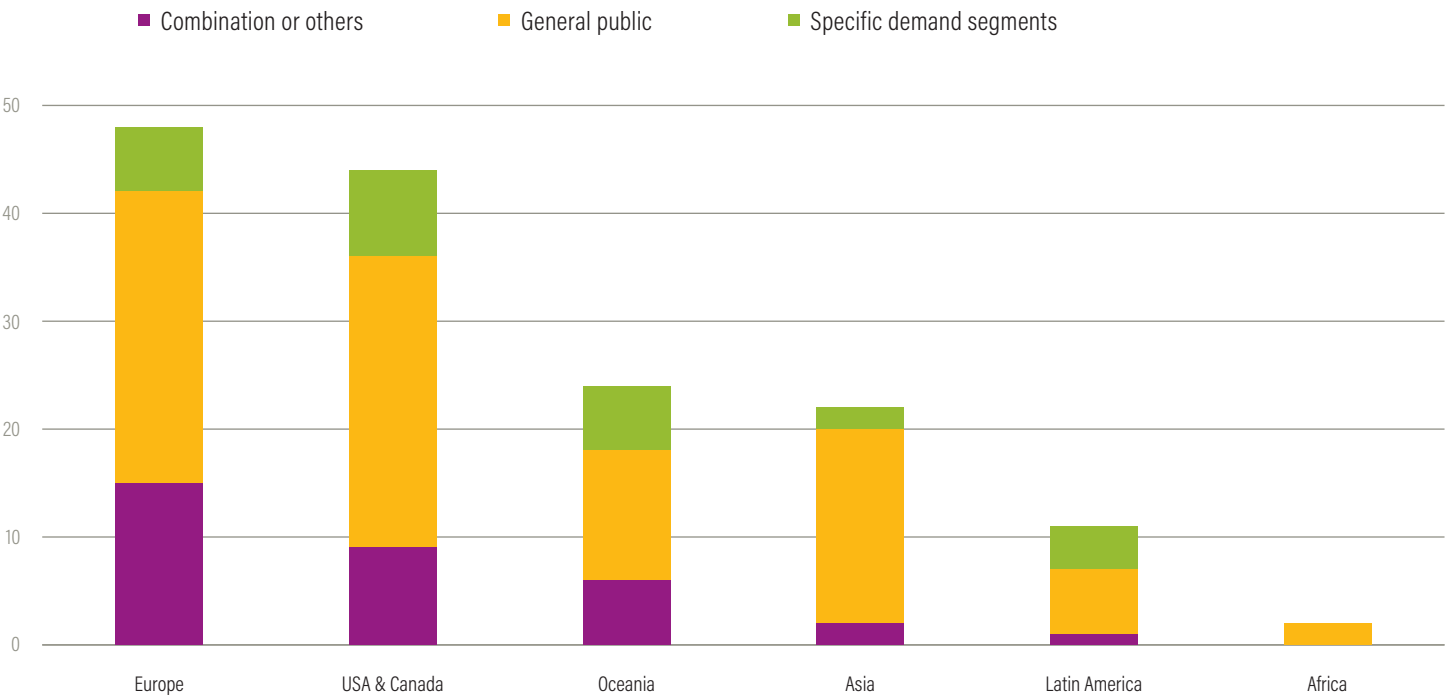
Our initial DRT data-gathering effort resulted in a non-exhaustive list of 151 cases around the world, with a heterogenous distribution (Figure 3). Most DRTs are found in Europe.[2] At country level, the world leaders are the United States and Australia. These two countries have a larger share of DRTs for specific demand segments than do European countries. But more interesting is the large concentration of cases in developed countries, accompanied by a limited number of developing countries in different regions, like India, Brazil, Mexico, Egypt, Bangladesh, and Indonesia.

When observing the distinction between users served, we note that most systems identified in this list serve the general public (92), and a smaller number are designed to meet specific demand segments (26), with some falling into a combination of both (33).

Figure 2 | **The Place of DRT in the spectrum from private car to traditional fixed-route transit**

Source: Adapted from Kirby et al. 1974.

Figure 3 | **Distribution of Sampled DRT Types, by Region**



Source: Authors based on dataset 1 (Appendix B).

3. DRT SERVICE TYPES

This study proposes a functional DRT classification by service type, which consolidates and updates previous literature proposals[3]. The classification is based upon surveys, interviews, and analyses that are part of this project:

- Paratransit services
- Corporate and university services
- Intercity and inter-region services
- Specific destination
- Night services
- General public services, a broader category covering trips with no specific destination or user segment[4]. This type of service is the primary focus of this study, given how prevalent it is in the total cases studied and its importance within transit systems.

Although there are cases that do not fit exactly into one category and there is a certain amount of overlap among service types, this structure offers a general classification framework that is useful for analyzing DRTs.

Paratransit Schemes

Paratransit is transportation exclusively for people with disabilities or reduced mobility, and until recently, was a very common sort of demand responsive transit. It was one of the first transit modes that operated on demand, where supply responded to short-term user requests.

The first paratransit services preceded technological advances like smartphones and used simple scheduling methods to match origins and destinations. These systems were generally known as call-and-ride, and government or operators used call centers to log trip requests from users. Once calls were placed, the center planned routes, itineraries, and schedules to optimize trips for vehicles adapted for use by persons with particular mobility needs.

Today, many paratransit services have advanced technologically, although they preserve some characteristics of the call-and-ride systems. The primary transition between call-and-ride and IT-enabled paratransit was the possibility of scheduling online or via smartphones and the use of more advanced trip optimization software. And yet, operations have not changed much, given the special needs of users, such as adapted vehicles. For example, door-to-door services are still necessary; and routes, coverage area, and scheduling still need to be highly flexible.

DRT solutions reduce costs and are a good fit for paratransit services, which generally require government subsidies to meet needs and ensure universal accessibility. There are examples of Paratransit services that became DRTs in many countries, and the number of cases is trending upward (Box 2).

Box 2 | **Examples of paratransit services**

The United States has a strong tradition of paratransit services, because of the Americans with Disabilities Act (ADA). Various authorities have developed technology to make them true DRTs, including Boston (Massachusetts Bay Transportation Authority n.d.), Central Florida (Lynx 2018), Maryland (Maryland Department of Transportation 2018), Napa Valley (VineGo n.d.), among others (Volinski, 2019). The Massachusetts Bay Transportation Authority implemented an On-Demand Paratransit Pilot Program in partnership with TNCs Uber, Lyft, and Curb, using these companies' apps for the city of Boston and its surrounding areas (Massachusetts Bay Transportation Authority n.d.). In the southern hemisphere, the service Atende+ in the city of São Paulo (Brazil), has more than 400 vans in operation, and is transitioning from a traditional paratransit service to an on-demand service, including smartphone hailing (São Paulo Transporte S/A n.d.).

Source: Survey and interviews conducted by Authors.

Corporate and University Schemes

On-demand corporate and university transportation models are also among historical precursors. They evolved from call-and-ride services, where users could schedule pick-up and drop-off by phone. However, they lacked the technological component that allowed for the proliferation of DRTs—real time route scheduling and optimization.

The first experiments and pilot projects took place in these simpler settings, without transport systems or complex demand factors, but with the advantage of on-site technical expertise. New matching trips and route optimization for trip sharing could be initially tested, to allow gradual technological advances.

Corporate and university models seek to leverage DRT efficiencies to provide internal trips for people who work or study on corporate or campus sites. Instead of a regular service with fixed schedules and routes, the company or campus administration opts for more flexible services, which reduce costs by optimizing supply. Operations usually use no predefined itinerary, although they are generally limited to the confines of the university or corporation.

University services may or may not be integrated with other transport modes off campus. However, some services cover several campuses. In this case, services are generally restricted to bringing users from one campus to another, and there are not many stops to get on or off outside of campus.

From an institutional perspective, there is little interaction between private university administration or companies and public transit authorities. The corporate/university structured model is typically private and serves specific users, but some exceptions use mixed institutional arrangements (see Box 3).

Box 3 | **Examples of corporate and university services**

One case of mixed institutional arrangement involves the University of Padua, where the service operates in partnership with the government to offer night services focused mostly, but not exclusively, on students. Trips are taken all over the city and region, but because the partnership to develop the pilot arose from a joint initiative between the University of Padua, the city, and the company Busitalia Veneto, most users are university students. The pilot was extended and is supported by a technology solutions company called Padam-Mobility (2020; PadovaNET 2020).

Conversely, some DRT companies that commonly operate general public systems, like Cityflo (n.d.) and Shuttl (n.d.; The Economic Times 2019) in India and Jetty (n.d.) and Bussi (n.d.) in Mexico, also offer on-demand corporate services. Those companies generally do not own their own fleet but operate in association with transport firms that own and operate the fleet, and use the existing technological and administrative capacity and brand recognition to expand the market and diversify operational areas.

Source: Survey and interviews conducted by Authors.

Intercity and Inter-regional Schemes

Not all DRTs are restricted to a single city or metropolitan area and some operate between different cities or regions. Intercity bus services are essential and have been around for decades in many countries but are normally organized along rigid routes and timetables. The technological advances that allowed for the boom in shared transport have also led to a rise in on-demand service applications for regional passenger transport markets (see Box 4).

Intercity or inter-regional DRTs are platforms upon which the user can schedule a trip from one city or region to another. This service can be on-demand because times and departure and boarding points can be flexible. In some cases, a vehicle is only brought into operation when a certain threshold of passengers has registered on the platform. This is how costs are kept down to improve economic performance. Furthermore, some companies specializing in this service have intermunicipal itineraries readily available on their apps.

Box 4 | **Examples of intercity/inter-region services**

As with taxis when TNCs were introduced, DRT applications for inter-regional travel became the competition to longstanding services. In Brazil, regional bus (intermunicipal) services operate as public concessions. The entry of bus ridesharing companies led to heated legal disputes, some of which have led to the suspension of operations on specific routes; in other cases, the continuity of intermunicipal DRT services was guaranteed. There are at least three companies of note in Brazil, a large country in which road transportation is particularly strong. Buser (n.d.), 4bus (n.d.) and Levebus (Levir n.d.) do not own a single bus, but act as intermediaries between users and drivers. They are considered the "Ubers" of long-distance bus services.

Like e-hailing companies, Buser, 4bus and Levebus are shaking up the traditional Brazilian market, despite their legal troubles (Diário do Transporte 2020a; 2021). This has led to some traditional companies creating specialized services, like Aguiaflex and Wemobi (Diário do Transporte 2020b), to compete with newcomers (Molica y Vieira 2019). These schemes share some features of DRTs, including smartphone access and flexible boarding and alighting stops, without the need to go to a terminal. However, schedules are not necessarily demand-responsive. This scenario is rapidly evolving.

Source: Authors.

Specific Destination Schemes

In specific destination schemes, DRT provides an exclusive means of transportation to or from a significant trip generator. The obvious example is airports, which normally have direct services, based on fixed schedules and routes, with little or no flexibility. These services still exist in many cities without incorporating demand-responsive characteristics, but the possibility of smartphone or internet scheduling of a trip on-demand allowed for the creation of a different kind of DRT specifically to serve travelers to and from airports (or other trip generators such as hospitals).

Routes can have diverse levels of flexibility (see Section 5), as long as the hub is the origin or destination. There is some variability in this type of DRT. Some services are door-to-door, similar to taxis, but using higher capacity vehicles. Others are restricted to connecting the hub to the Central Business District (CBD), neighborhoods with high airport travel demand, points of interest or secondary transportation hubs that allow access to the rest of the city.

Box 5 | **Examples of specific destination services**

Specific destination DRTs are designed for a market niche defined both by a particular origin or destination, and by a specific audience. An example is the company Super Shuttle (n.d.), which operates around airports in the United States as well as in some Latin American and European countries. The company specialized in serving airline passengers, who wanted alternatives to conventional transit. Although private vehicle rides were also offered, Super Shuttle's main business from the beginning was shared rides that gradually assumed characteristics of DRT-like demand-responsiveness. At its peak, the distinct blue and yellow vans worked in more than 100 cities (Burns 2019). However, in December of 2019, the media reported that the company had filed for bankruptcy and would cease activities in 2020, due to changes in legislation and competition from e-hailing companies that had substantially increased operations at airports (Gilbertson 2019).

Source: Authors.

Night Service Schemes

Night services are quite similar to the General Public group, as they are not restricted to a certain type of user, but their trip characteristics are specific and constitute a demand that deserves to be treated as a distinct DRT type. Some cities offer on-demand night services since nighttime operations are well suited to DRT advantages (see Box 6). Because trip density falls at night, serving a smaller and more scattered public, route optimization and greater itinerary and schedule flexibility allows for cost reductions, while maintaining minimum frequency levels to ensure an acceptable quality of service.

The cases compiled for this study suggest that there is no single or predominant operational model that broadly covers all types of night services, other than the time period (generally between 9:00 pm and 4:00 am, with local variations). Sometimes, night transportation is just an extension of day operations.

Box 6 | **Examples of night services**

Belleville, Canada operates a night DRT system with no fixed routes or schedules. The pilot project was intended to substitute for conventional night bus lines, which covered long routes and ran a budget deficit. By freeing itineraries and schedules, this flexibility brought new routes and more users could be served, which allowed for greater savings. Although the pilot ran only between September 2018 and January 2019, many lessons were learned. The first is that that it was important for the project to use existing transit infrastructure: rather than creating virtual stops, it made use of existing stops. Another lesson is that not all users are prepared to make the technological leap, which is why it was important to allow ad hoc boarding, so anyone who did not have the app could get on the bus and be counted in the ticketing system (Mellor 2018; Postmedia Staff 2019).

Singapore introduced a system that extended service from daytime demand. The Land Transport Authority (LTA) pilot had already planned to test options during off-peak hours, and it made sense to add night lines as part of this temporary operation. The agency discontinued one of the regular night lines, and substituted it with on-demand buses, using lines predefined between the CBD and city suburbs, but with greater itinerary flexibility. The night service was less flexible than the day service, which focuses on bringing workers home from the city center at the end of business day. Therefore, there was a well-defined region of origins and destinations and however varied the routes, they passed through corridors that served to connect to neighborhoods and bedroom communities (Land Transport Guru 2018; Channel News Asia 2019).

Source: Survey and interviews conducted by Authors.

General Public Schemes

The General Public DRT group covers a wide variety of on-demand services covering a multitude of trips taken in cities for different purposes (work, school, shopping, etc.), to and from different origins and destinations, and without user restrictions. Hence, this type of scheme has the highest degree of overlap and interaction with conventional transit systems (see Box 7). Most of these cases are located either in medium and high-density urban centers or in much lower density suburbs and towns. The flexible nature of DRTs allows for experimentation and development of a wide range of solutions. Rigid classification is therefore both difficult and unwise.

Box 7 | **Examples of General Public DRT Schemes**

An interesting pilot case is that of the Singaporean Land Transport Authority (LTA). From the beginning, this system was designed to be an integrated part of the regular city-state transit, making fare and operation integration possible, with same fares as the regular system. Experimental daytime operations were engaged to operate in certain city commercial regions, traveling within specific perimeters. Different from most cases studied, the Singapore DRT works with the same size of buses as those used in regular transportation rather than using smaller vehicles. It also uses a flexible itinerary within a predefined area. Interestingly, the DRT and regular transit services use the same stops (Land Transport Guru 2018; Channel News Asia 2019).

Source: Survey and interviews conducted by Authors.

4. INSTITUTIONAL DIMENSIONS

We identify three dimensions of analysis to further distinguish among the characteristics of DRT implementation.

- **Institutional arrangements**: Is the DRT service created through public policy or in response to market opportunity (Enoch et al. 2004).
- **Integration with public transportation**: How does the DRT service relate to and interact with regular public transport systems that operate in the same city or region (Enoch et al. 2004).
- **Regulatory aspects**

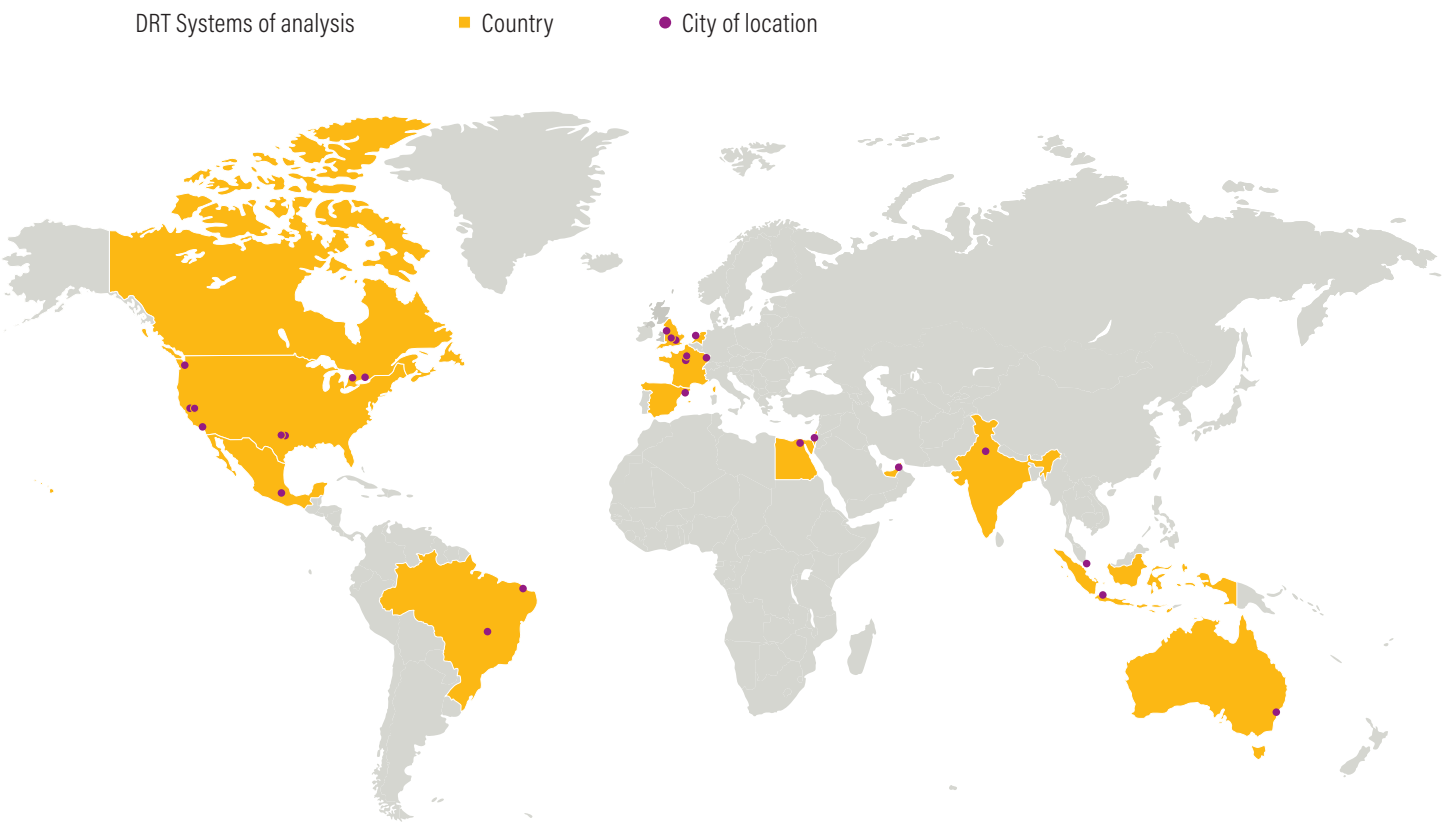
Figure 4 depicts the location of the DRT schemes that comprise dataset 2 (see Appendix F), which constitutes the basis of analysis in this and the following section. This dataset contains information collected and systematized for the 32 General Public DRT systems used in this study. It was elaborated from the survey (see Appendix D, DRT Survey Questionnaire) and supplementary information collected in publicly available sources, with data gathered and collated between December 2019 and July 2020.

Institutional Arrangements

According to Mulley et al. (2012), flexible transportation service development and provisioning can be categorized based on how it is conceived: top-down or bottom-up. In a top-down approach, the role of flexible services would be clearly defined as part of a public policy and planning process. Conversely, flexible bottom-up services are offered to meet market opportunities or introduced by private operators to reduce operational inefficiencies, for example, by cutting down the number of buses. This can be necessary even when the government subsidizes operations and specifies the level of service.

- **Market-Based Services:** When we look at General Public DRTs, services created to meet market demand are generally more private sector-based businesses than public policy-based. This is the case with Jetty, Bussi and Urbvan in Mexico, TopBus+ and CityBus 2.0 in Brazil, Shuttl and Cityflo in India, and UberBus in Egypt. Services are formed by private associations, and may involve different combinations of transport operator companies, drivers (individuals or grouped in formal organizations or companies), and technology platform suppliers and administrators (which

Figure 4 | **Location of the Demand Responsive Transit Cases Analyzed**



Source: Authors.

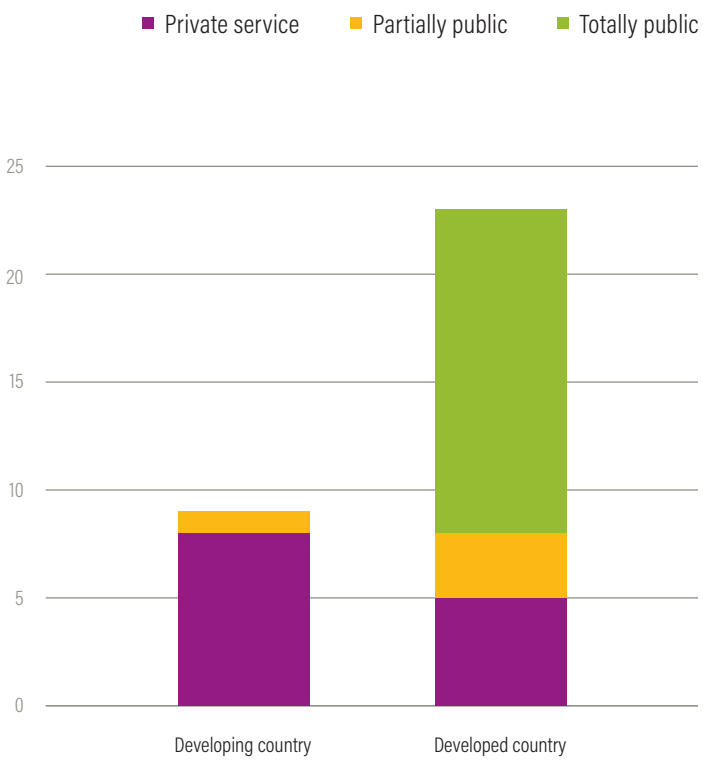
typically include the front-end of smartphone apps and the back-end supply-demand matching and vehicle scheduling algorithms). The government is rarely actively or directly involved in the service provision and is limited to enforcing applicable legislation or DRT-specific regulation when it exists.

- **Public Policy-Based Services:** Governments generally contract for the DRT service, either directly or through a concession combining DRT technology providers (for example, Via, PADAM or BRIDJ) and conventional transportation companies in a consortium. Institutional arrangements can vary. For example, the service may originate as an initiative from public-private consortiums, like LA Metro Mobility in the United States, *Transport à la demande* in France, BerlKönig in Germany, and Go Sutton in the UK. These are partially public systems, where the DRT is a private service with some level of integration with regular transit system; the objective is to leverage DRT technological advantages to improve public transportation quality with greater efficiency and comfort.

Other DRTs are fully integrated into a city's public transit system, following a government decision to reduce operational costs and improve service. When outsourced to private companies, the app management role can be contracted by a bus operator company, like the Shotl system in Spain, BRIDJ in Australia and bubbleDan in Israel. Alternatively, a government office or city transit agency can do the contracting, as is the case with 100 percent demand responsive systems in the United States (DART GoLink, Smartride, Arlington on Demand, West Sacramento on Demand); the feeder service Résa'Tao in France; KVV MyShuttle in Germany; and the pilot On Demand Public Bus Trial in Singapore.

The case studies indicate that General Public systems in developing countries are largely private sector or market-driven initiatives, whereas in developed countries (mainly

Figure 5 | **Institutional arrangement of DRT systems in developing and developed countries**



Source: Authors, based on dataset 2 (Appendix F).

cities) General Public DRT schemes are predominantly driven by public policy and implemented by governments (Figure 5). The city of São José dos Campos will probably be the first case in a developing country of a government-sponsored DRT that is totally integrated with the regular transit system. A public tender is planned for 2021 for the next public transportation concession.[5]

Specific user group DRTs, such as corporate and universities schemes, are usually operated privately and there is little interaction between university administrators or companies and government transportation agencies. There are some cases of mixed institutional arrangements, for example, University of Padua scheme mentioned earlier (Box 3)(see Corporate/University, Chapter 2).

Whether public or private, DRT models—like ride-hailing—do not generally involve technology companies owning the fleet or hiring drivers directly. However, unlike ride-hailing models where drivers are treated as autonomous workers[6], in DRTs technology providers generally enter a partnership with passenger companies, which are then responsible for fleet acquisition and hiring drivers.

Integration with Public Transportation

DRTs may be integrated with regular public transportation in different ways and to different degrees. We examine issues of operational mode, institutional arrangements, and fare integration, under three proposed models, or categories, of operation.

Competitor model

Competitor model DRTs overlap and compete with public transport, operating in a range of market niches (see Box 8, next page). Competitor DRTs tend to be developed and controlled by private companies to meet a specific market niche, with little to no governmental interaction or control and no fare integration with public transit. Users may choose to transfer to other modes of passenger transport, but this occurs spontaneously, not as a result of public planning. Thus, an important point is that competitors do not necessarily operate as a public service and do not try to incentivize or facilitate their users' integration into the public transportation network. Competitor DRTs are essentially parallel services that compete with public transit for passengers. Executive or premium services mostly belong in this category, as they can directly compete with regular public transport, but can also compete with ride-hailing and personal private transport[7].

Supplementary model

Supplementary model DRT schemes are integrated with public transit to some degree, and operate in support of the system as a whole (see Box 9, next page). Users can be encouraged to use a DRT in combination with other services through design of perimeters or corridors associated with transit hubs—a form of physical and operational integration. For example, feeder systems are designed to offer a connection between the user's origin or destination and a transportation hub such as a train, subway, or BRT station (see Box 10, next page). Most General Public DRT services with integration are feeder systems. They operate around one or more hubs predominantly away from city centers—in residential areas, suburbs or rural regions—where long distances and low population density make conventional transit more costly. DRTs are a logical solution for such places, as they combine flexibility, especially during off-peak hours, and cost reduction. However, a risk is that feeder services can be reduced in places where

supply is already low, which compromises accessibility for entire neighborhoods if not done carefully.

Box 8 | Examples of the competitor DRT model

Some competing DRT schemes are quite similar to regular public transportation, in that lines are largely fixed, and adjust for demand over the medium and long-term. This is the case with the companies Jetty, Bussi and Urbvan, which run in Mexico City. Based on market knowledge and data supplied by apps, they were able to find demand niches that could potentially transform into frequent-service fixed routes. Once a sufficient level of demand is met for a certain destination, new routes or variants of existing routes are launched by the operators to expand their share of the transit market. Conversely, if there is insufficient demand, a route can be quickly terminated or replaced with an alternative. In this case, route optimization algorithms do not identify real-time boarding and alighting to define a user pool with similar destinations who will board the same vehicle. However, historical demand data (supplemented by other information sources on demand, population, and trip generators) are used to ascertain potential demands that justify the creation of services. This DRT model has been successful in countries in the global South. Besides Mexico, research also identified similar systems in Egypt (Uber Bus) and in India (Shuttl and CityFlo) (Chadha, Shetty, & Shastry 2018).

Another successful form of non-integrated or competitor DRTs are those that mostly operate around Central Business Districts in large metropolitan areas or in an expanded perimeter around a city center. Examples include the consortium ViaVan in Amsterdam and London (n.d.); many schemes in the United States such as Via NY (n.d.) (New York), Pick Up (Capital Metro n.d.) (Austin), or CityBus 2.0 (n.d.) (Goiana); and TopBus+ (n.d.) (Fortaleza) in Brazil. Other examples were found in Australia (Transport for NSW n.d.), New Zealand (Auckland Transport n.d.), Asia, and other European countries. There are no restrictions to routes, origins, or destinations that drivers should follow. Generally, a coverage area is defined, and vehicles can provide rides only within its boundaries. This service is fully demand responsive in real time. Routes, boarding, and alighting are all defined by optimization software without restriction or prior scheduling. It works like a pooled taxi, but using a matching algorithm, that seeks to find the best route that simultaneously meets the trip requirements of various users at the same time—a true rideshare. However, there is no guidance or software standardization for the service to connect to public transportation. Route optimization is based solely on user origin and destination. This model's flexibility has made it highly successful.

Source: Survey and interviews conducted by Authors.

Supplementary alternatives generally arise via government initiatives or public policy driven public-private consortiums (expansion of existing concessionaires, or new public tenders). The principal motivation in these cases is using DRT technological advantages to improve public transportation.

Box 9 | Examples of the supplementary model

FlexHop is an example of a system that serves low population-density areas and has largely replaced regular public transport in the rural and peri-urban region of Strasbourg, France. Thirteen regions are covered by the service, which has fully integrated fares. Under the criteria defined above, FlexHop may therefore be considered the product of public policy, rather than a private service. The government realized that a DRT service for the entire region would be advantageous and launched a competitive bid tender to interested companies. Models similar to Strasburg are common in other European countries including Spain (Transladem n.d.), Italy (Padam Mobility 2020) and Germany (Moobil n.d.). There are also cases in Australia (LiveBetter n.d.) and the United States.

Source: Survey and interviews conducted by Authors.

Box 10 | Examples of a supplementary feeder service

The service TAD IDMF (Padam Mobility), which operates in the Parisian suburb of Île-de-France, is an example of a versatile feeder service used to optimize fleet use during off-peak hours. During peak hours, when many passengers are traveling to work in the densest regions of the city, the service plays a classical feeder role, connecting residential areas to the high capacity systems like rail networks. It is possible to set the software parameters to schedule a bus to arrive at a station shortly before a train leaves, minimizing waiting times. During off-peak hours, vehicles are used for local travel, and are not necessarily tied to transportation hubs (Transport à la Demande n.d.)

Another example of a feeder model is a public pilot project for LA Metro, in Los Angeles. Partnered with the company VIA, LA Metro developed a pilot project for low-income users in three different regions of Los Angeles County. The government subsidizes investments to make the project feasible and accessible. The service, which is free of charge, focuses exclusively on connecting residents to three transportation hubs (Los Angeles Metro 2019).

Source: Survey and interviews conducted by Authors.

Substitute model

Substitute model DRT schemes take the place of public transport, typically in places where it been discontinued in favor of on-demand services. Some cities and regions have entirely replaced their public transport operations with on-demand services. The substitute model is similar to the supplementary in that it results from public policy. The decision to replace regular public transport partially or totally is generally a government decision, which may either outsource the DRT services to private companies, or plan and operate them directly (see Box 11).

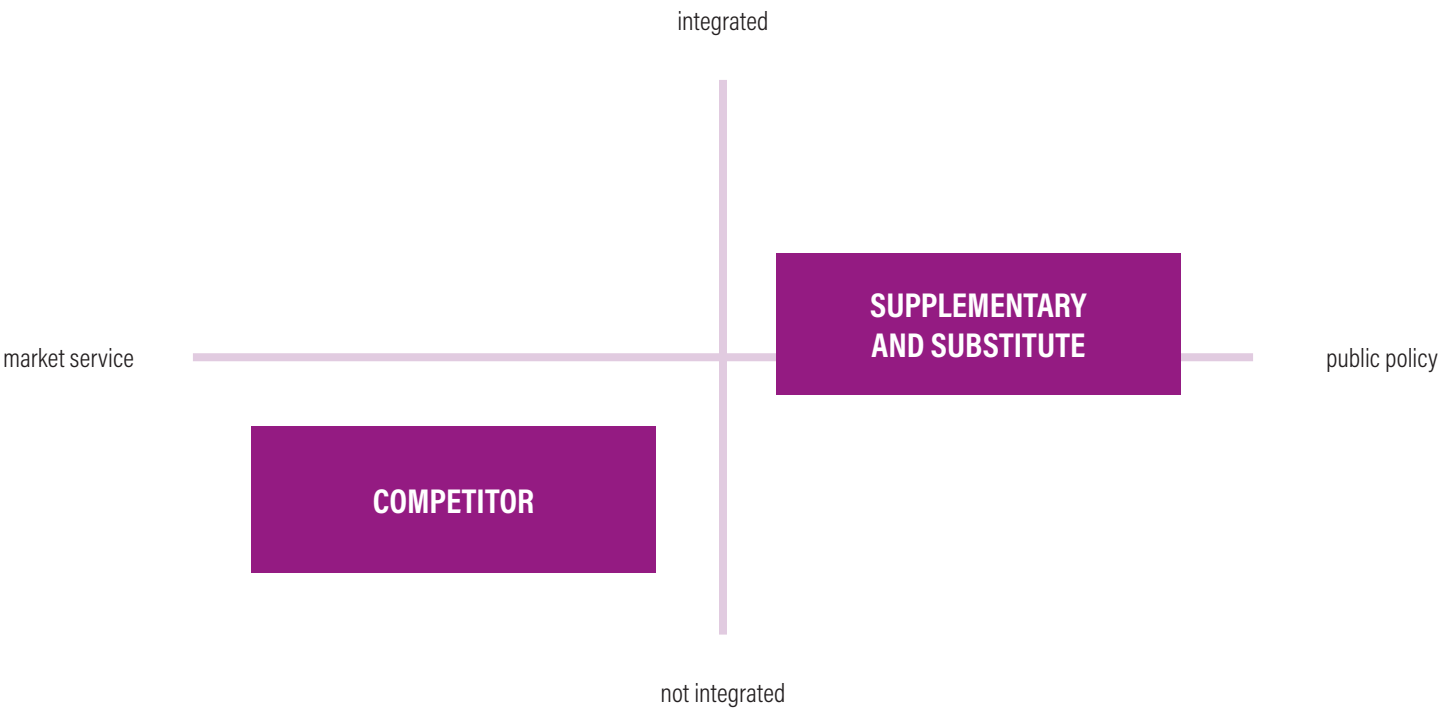
The examples of the three models indicate that, the more DRT is conceived in a top-down approach, as a public policy, the higher the likelihood it will be integrated with the regular transportation network from the start, reinforcing the insights of Mulley et al. (2012) (Figure 6).

Box 11 | **Example of the substitute model**

On weekdays, the DRT in Belleville (Canada) only operates at night, on weekends the only service offered is a daytime on-demand service, which runs from 5:30 AM to midnight on Saturdays, and 8 AM to midnight on Sundays. At these times only, regular operations are replaced by demand-responsive operations. Since on both night and weekend day operations the DRT runs through the city, it qualifies as a totally integrated service. This case stands out as a creative way to use substitute DRT when it makes sense (weekend days and nighttime), to meet specific local needs (McLeod 2018).

Source: Survey conducted by Authors.

Figure 6 | **DRT Models: Institutional Origin and Integration with Public Transport**

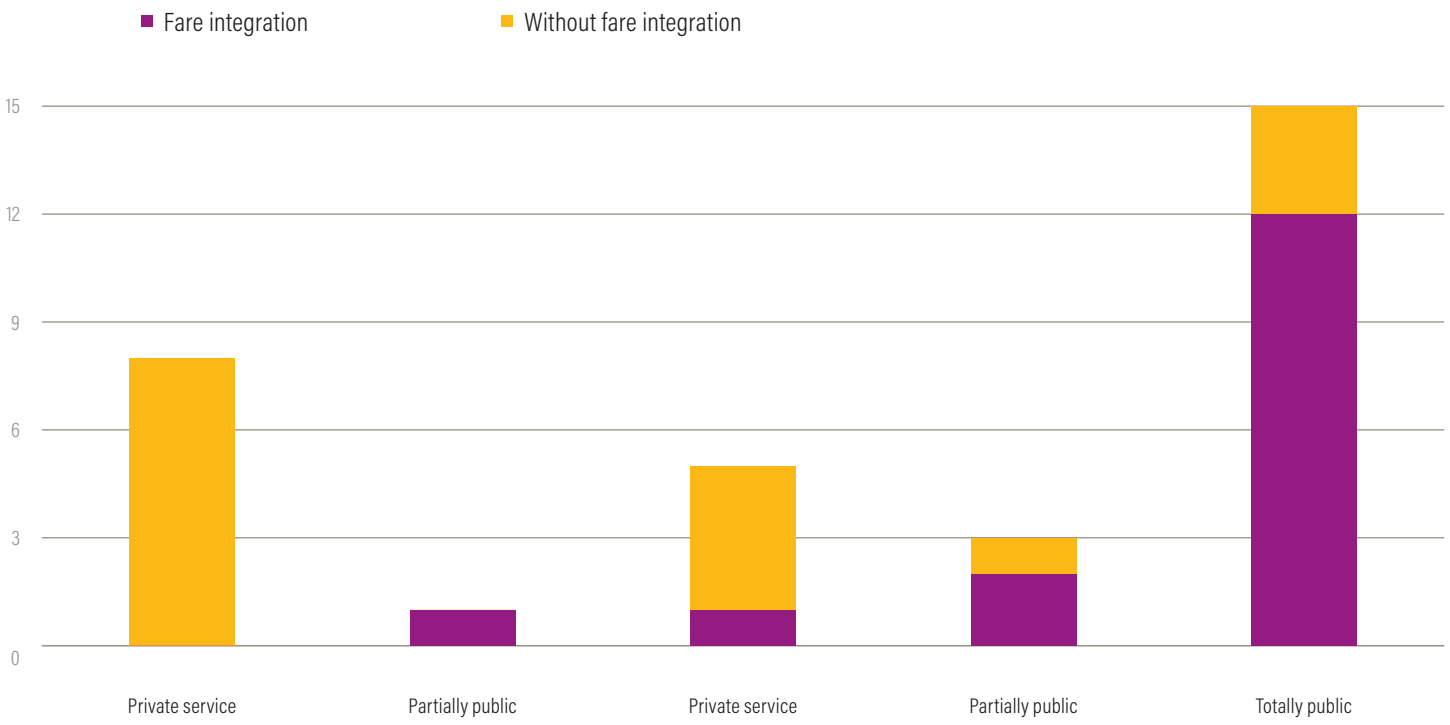


Source: Authors.

- **Fare Integration:** A DRT is not fully a part of a city's public transportation system unless fares for the two schemes are integrated. Among DRT service types, only paratransit or night services, in supplementary or substitute models, achieve fare integration. This happens because these DRT services are typically the result of diverse government policies (even in some subsidized or free-of-charge cases).

Likewise, general public DRTs show a clear pattern: most private services have no fare integration, whereas nearly all cases of fare integration with regular public transit operate as partially or totally public services (Figure 7). Nearly all fare-integrated systems are located in developed countries, as for example Ilê-de-France, Strasbourg, Los Angeles and Sydney, while most systems in developing countries operate without fare integration.

Figure 7 | **Integration of DRT and Public Transport Fares, By Region**



Source: Authors, based on dataset 2 (Appendix F).

Regulation

Specific DRT regulations tend to be found where DRT schemes are connected to a city's regular transit system, and consequently, to the institutional arrangement involved. However, every location has its own legal and regulatory framework, and the treatment of DRTs is specific to each. A systematic understanding of DRT regulatory aspects would require a study beyond the scope of this work, but our research offers some insights into regulation of DRT services.

There is great legal and institutional diversity, especially within non-integrated DRT models. Competitor model DRTs, for example, are mostly private initiatives that sometimes simply try to carve out a space within the existing legal framework. Despite not originating from public policy, these services generally end up being regulated to some extent by authorities (local, state, or national, according to each situation). In Mexico and Brazil, different solutions were found in cities which lacked specific regulation applicable to DRTs. In Mexico, DRT companies like Jetty, Bussi and Urbvan managed to be classified under regulations created previously for ride-hailing companies like Uber, Cabify and Didi. In Brazil, Goiania's and Fortaleza's DRTs were implemented through existing bus operator concessionaires as a separate non-integrated "premium" service that qualified as an added benefit offered to the population under the current concession contract with the municipalities. An exception to this approach is UberBus in Cairo, Egypt, the only system that operates under a specific DRT regulation.

Companies that operate in multiple countries need to adapt to each context and abide by local laws. That is the case of Via and Padam, which, for example, were able to develop systems more quickly in France, where regulation applicable to DRTs has been around longer. In other European countries like Spain and Portugal, where there was still no specific DRT legislation, it was necessary to adapt ride-hailing laws.

Supplementary and substitute models are highly complementary and integrated with regular transit. They tend to be included under conventional public transportation system regulation or even operate without the need of a specific regulation as they were conceived from the outset as an integral part of the existing transportation network.

5. DRT ATTRIBUTES

In Section 3, we identified and classified DRT service types; however, there are variations within each type, found mainly in the general public DRTs. This section discusses these variations, organized according to what we call "attributes". As with the previous section, this section is based on Dataset 2, comprised of 32 General Public DRT cases. The attributes include:

- Route flexibility
- Geographic coverage
- Vehicle type
- Request method
- Payment method
- Pricing

Route Flexibility

Route flexibility refers mostly to the degree of restriction or freedom of stops and itineraries. The more flexible the route, the more the service resembles TNCs, in that it is more responsive to real-time demand. In these cases, routes as well as boarding and alighting stops are defined by optimization software, with different levels of restriction or advance planning.

There are many different types of flexible transportation services and variations within each one. Trying to develop a common taxonomy for different types of transport services based on route flexibility is a challenge that the literature has taken on several times. According to Denmark (2012), there are four basic types of flexible transport service types (Figure 8, next page):

- **Route deviation with fixed stops:** Vehicles operate along a main route with fixed stops and can deviate to serve passengers inside a buffer zone within the main route.
- **Point deviation with fixed stops:** Vehicles run within a zone or corridor where there are some predefined stops, but no main route.

- **Destination demand responsive transport:** Vehicles are demand-responsive, but have defined destinations, and can be organized so as to arrive or leave from a destination at fixed times.
- **Pure demand responsive transport:** Routes are totally flexible to passenger needs and are the most flexible of all.

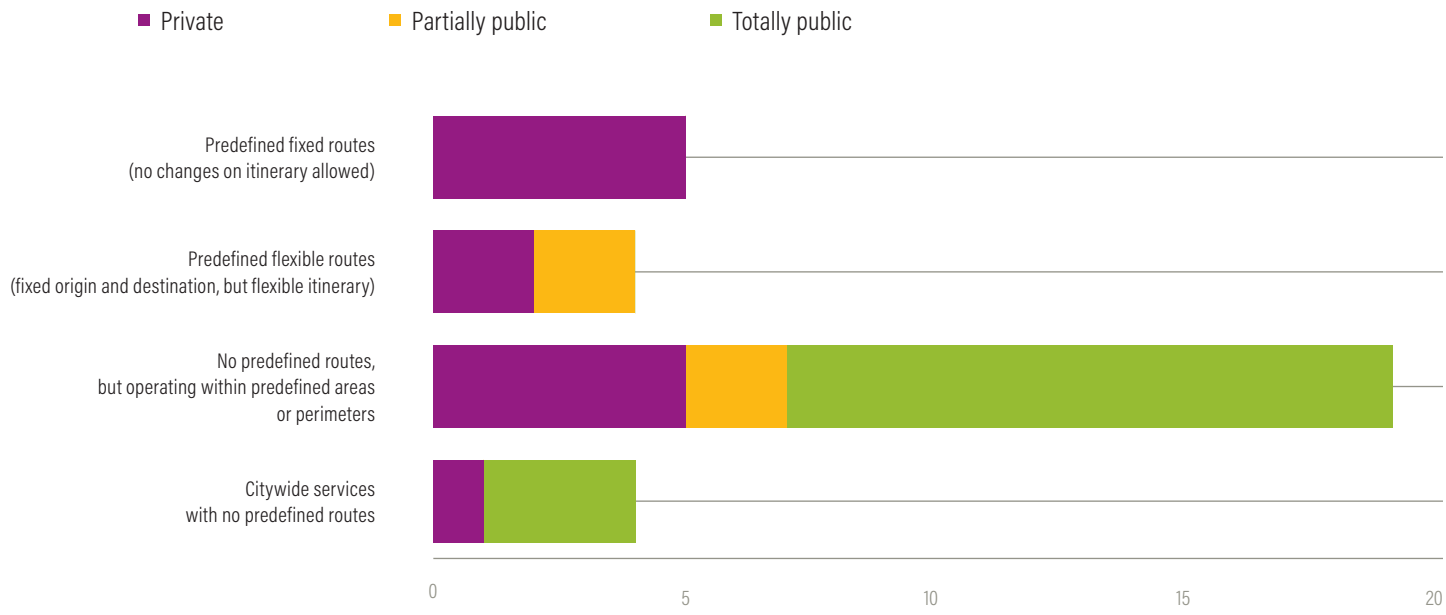
Most systems without predefined routes are public services, while most systems that operate along predefined routes are private (Figure 9).

The greater the responsiveness to demand in real time, the greater the tendency to be route flexible. Thus, in most systems for the general public, services operate freely, without predefined routes (see example in Figure 10). Exceptions are found in Mexico (see example in Figure 11, page 20), India, Egypt and France.

Figure 8 | **Different types of route flexibility in DRT services**

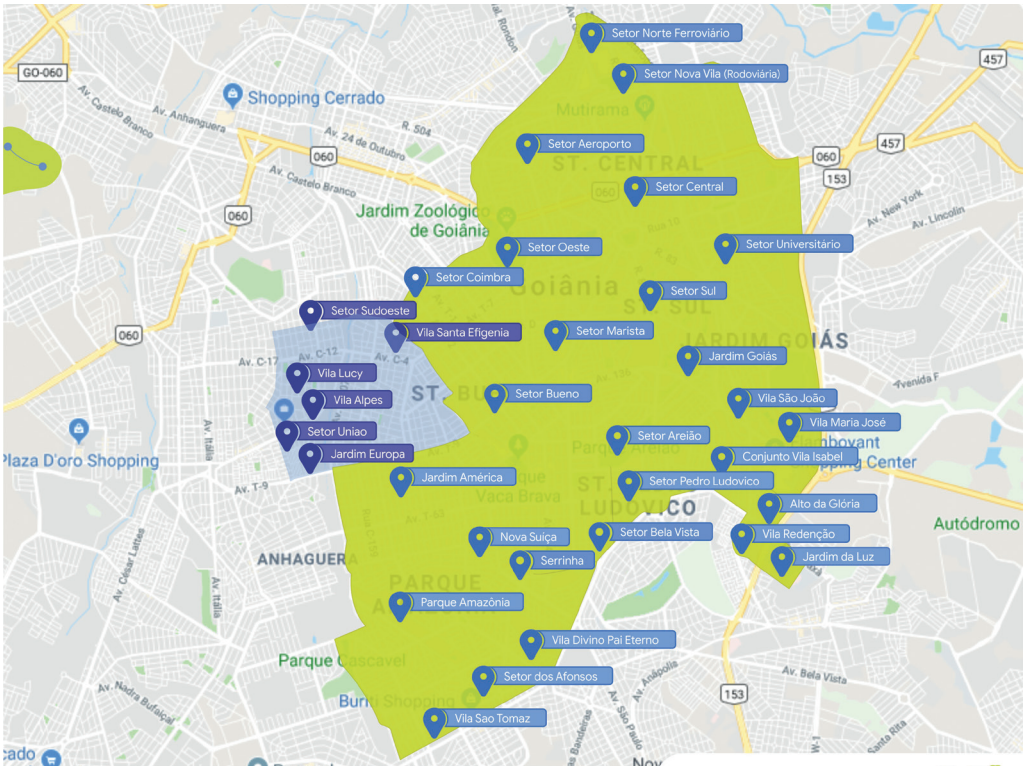
Source: Denmark 2012.

Figure 9 | DRT systems distribution based on route flexibility and institutional arrangement (public/private)



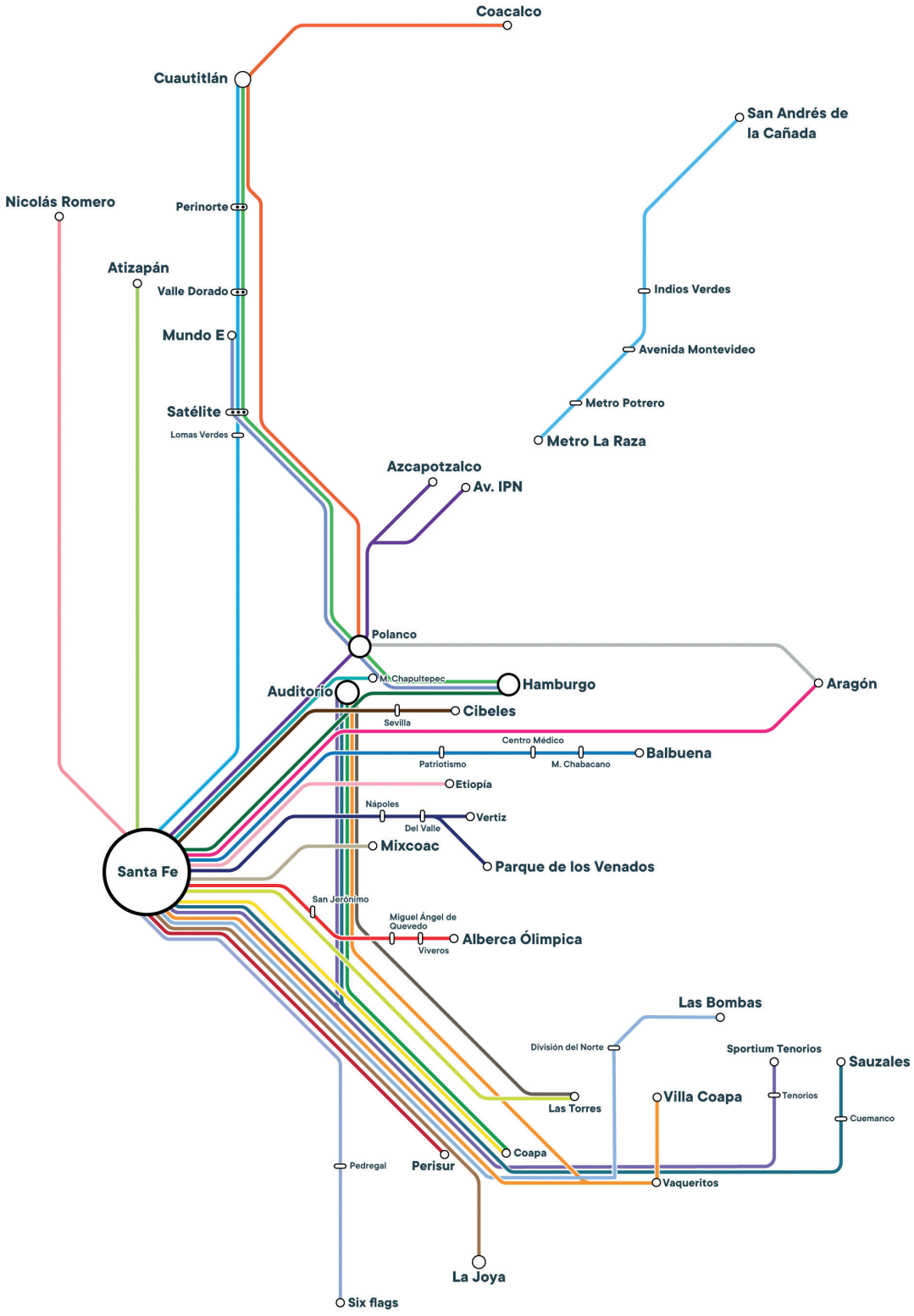
Source: Authors, based on dataset 2 (Appendix F).

Figure 10 | CityBus system coverage area, no predefined routes



Source: City Bus Goiania, Brazil.

Figure 11 | **Jetty system, pre-defined routes**

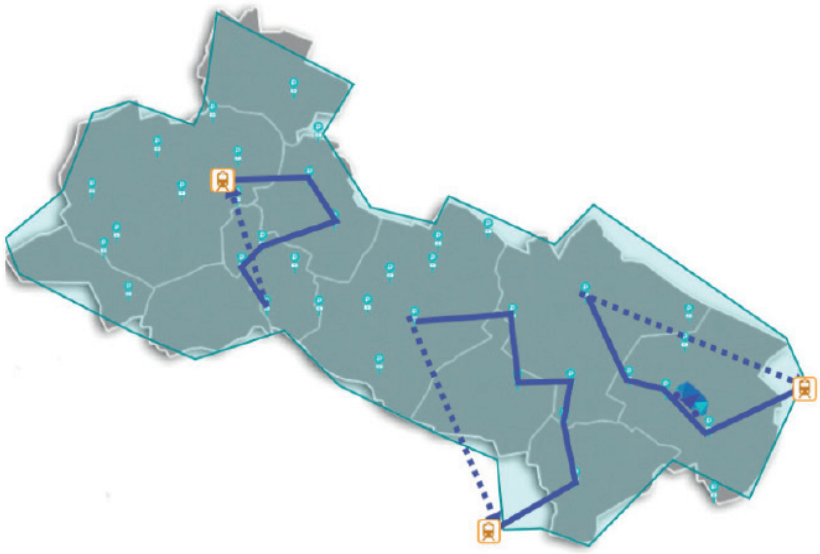


Source: Jetty, México.

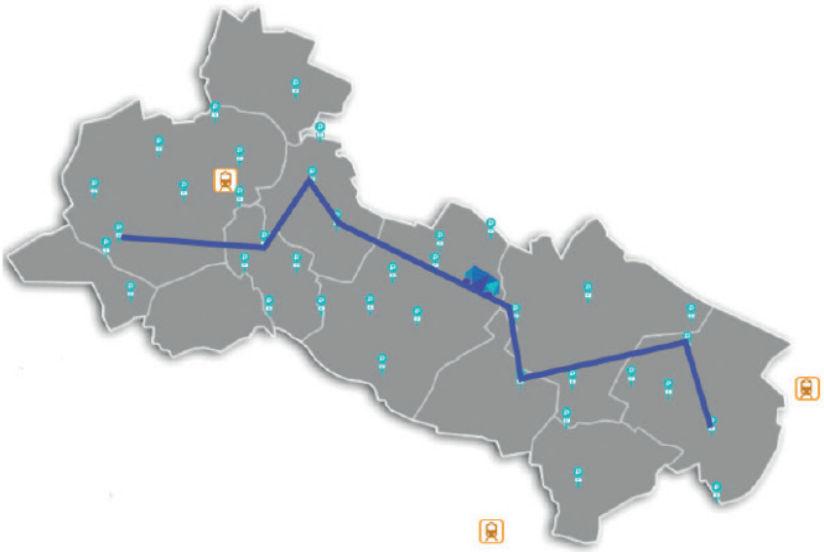
Route flexibility and responsiveness to demand, also observed in night services and paratransit, can be applied depending on the time of day. For example, Flexigo (Ilê-de-France), operates as a train station feeder during peak-hours, but at off-peak times runs with no predefined routes (Figure 12).

Figure 12 | **Flexigo route examples (Ilê-de-France-Padam)**

COMMUTING HOURS:
TRAIN STATIONS-TO-MANY



OFF-PEAK HOURS:
FREE FLOATING CONFIGURATION



Source: Pettersson 2019.

Geographic Coverage

Geographic coverage refers to the DRT spatial reach, which may be a state or metropolitan region; an entire city; smaller units, like neighborhoods or districts; specific transport corridors; or limited private zones.

Figure 13 shows a schematic classification from a UK report (Enoch et al. 2004), which shows under what circumstances the DRT systems should be considered in terms of scheduled service in relation to the system's coverage area.

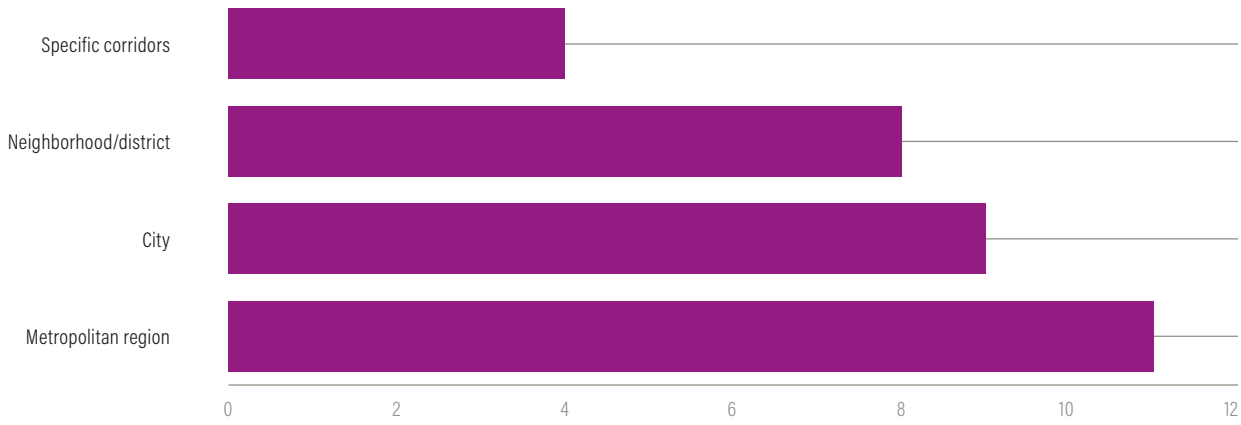
Figure 14 shows the geographic coverage distribution of the General Public DRT systems that were analyzed. Two-thirds operate over the entire urban area where they are located, with 11 systems in metropolitan regions and 9 systems citywide. A little over one-third of the schemes limit operations to more reduced areas, with 8 systems operating in neighborhoods or districts and 4 in specific corridors.

Figure 13 | **DRT schedule and reach**

TIME	PLACE				
	CITY RADIAL	TOWN RADIAL	CITY CROSS-SUBURB	FRINGE URBAN	RURAL
Monday-Friday 06.00-19.00	Conventional bus	Conventional bus	Conventional bus/DRT	Conventional bus/DRT	DRT
Monday-Friday 19.00-23.00	Conventional bus	Conventional bus/DRT	DRT	DRT	DRT
Monday-Friday 23.00-06.00	Conventional bus/DRT	DRT	DRT	DRT	DRT
Sundays	Conventional bus	Conventional bus/DRT	DRT	DRT	DRT

Source: Adapted from Enoch et al. 2004.

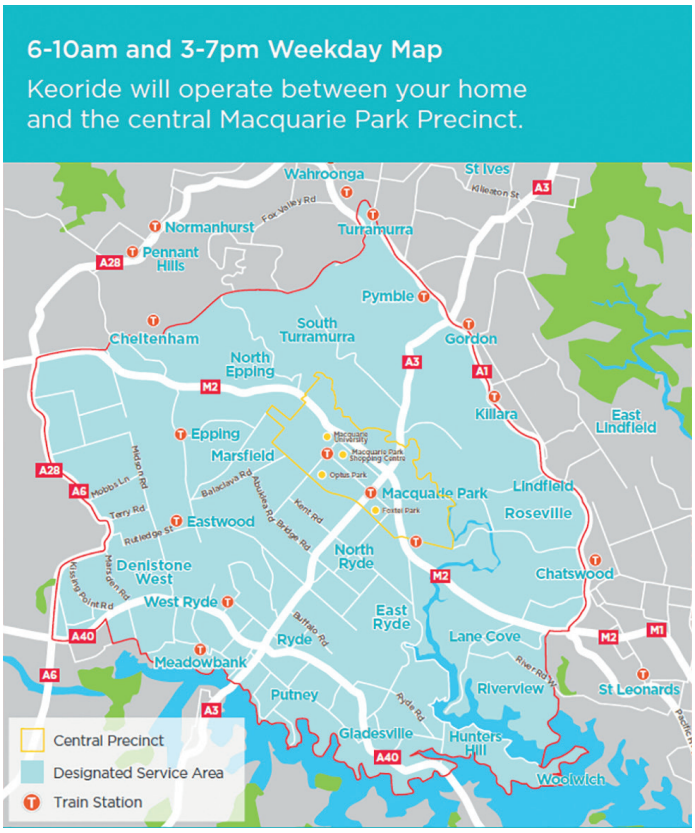
Figure 14 | **Coverage-based DRT system distribution**



Source: Authors, based on dataset 2 (Appendix F).

Systems covering specific corridors tend to have fixed routes, like Shuttl in Delhi NCR. Transit-integrated systems, like feeders, typically concentrate on specific city zones where regular transit offers a less efficient option for bringing passengers to the city's mass transit network. An example is the Keoride system in Sydney (Figure 15) and a Singapore pilot (Figure 16). However, some feeders serve entire metropolitan regions, like Résa'Tao in Orléans (Figure 17, next page).

Figure 15 | **Keoride system coverage area.**



Source: Keoride NSW, Australia.

Figure 16 | **Singapore pilot coverage area**

Source: Land Transport Authority, Singapore.

Figure 17 | **Résa'Tao system coverage area**

Source: Résa'Tao Orléans, France.

Some systems with high demand responsiveness in terms of route flexibility cover complete areas. Examples are PickMeUp, which covers the entire city of Oxford, UK and GoLink, which operates over the entire Dallas metropolitan region (Figure 18). In GoLink's case, the system is fully integrated with the public transportation network, including fare integration.

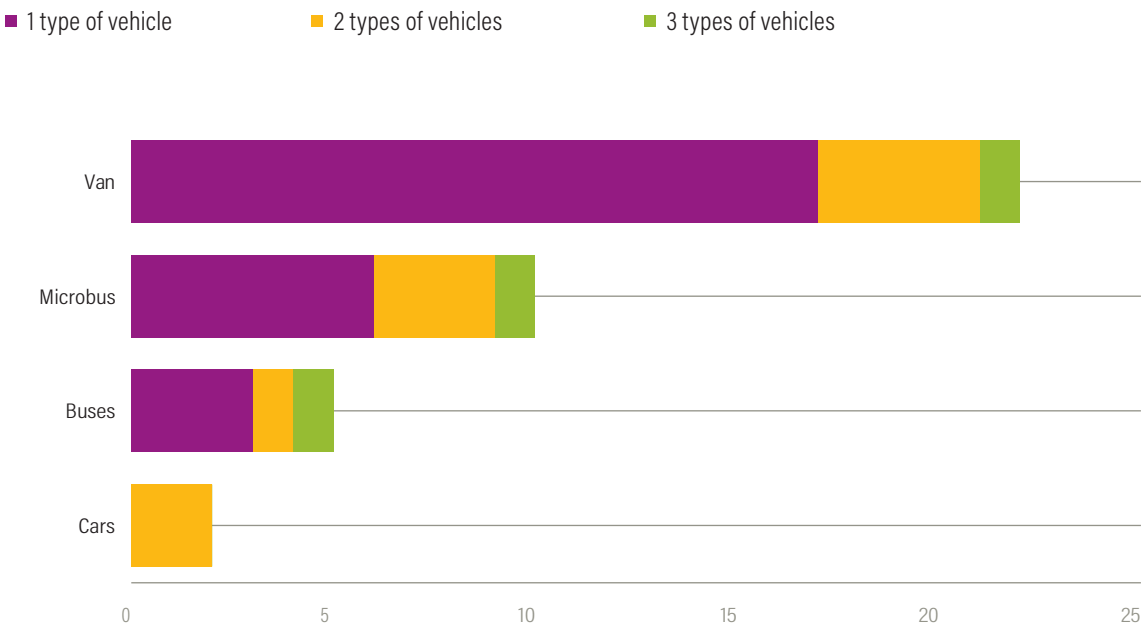
Figure 18 | **PickMeUp coverage area**

Source: PickMeUp Oxford, UK.

Vehicle Type

Fleets may comprise different vehicle types; 6 of the 32 systems analyzed operated with more than one vehicle type. The most common vehicles are vans, which are present in 22 systems, followed by microbuses (10) and buses (5). Cars are found more rarely, and always in combination with other vehicle types (Figure 19).

Figure 19 | **Distribution of DRT systems by vehicle type**



Source: Authors, based on dataset 2 (Appendix F).
Note: For this variable, multiple answers were allowed.

Vans are present in all types of DRT systems but are most prevalent in General Public systems. Microbuses and conventional buses are more common in specific user DRT types, like corporate/universities, intercity, paratransit, night service, and specific destinations (see Figures 20, 21, 22, 23).

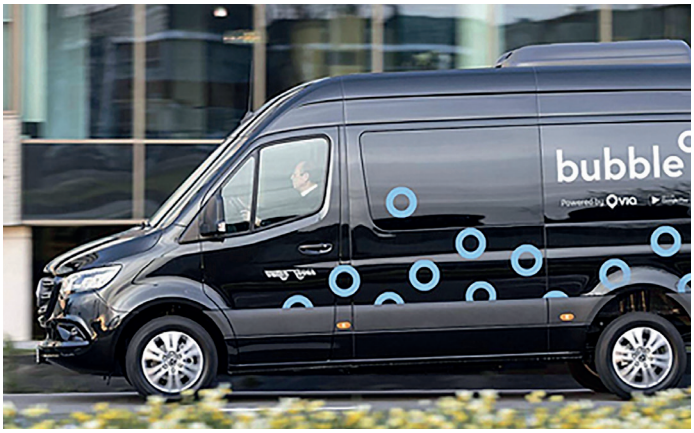
Figure 20 | **Singapore pilot bus**

Source: Singapore Business Review.

Figure 21 | **Belleville system bus**

Source: Ryerson City Building Institute, Canada.

Figure 22 | **Bubble Dan system van in Tel Aviv**



Source: Bubble Dan, Israel.

Figure 23 | **Urbvan system bus**

Source: Urbvan, Mexico.

Request method

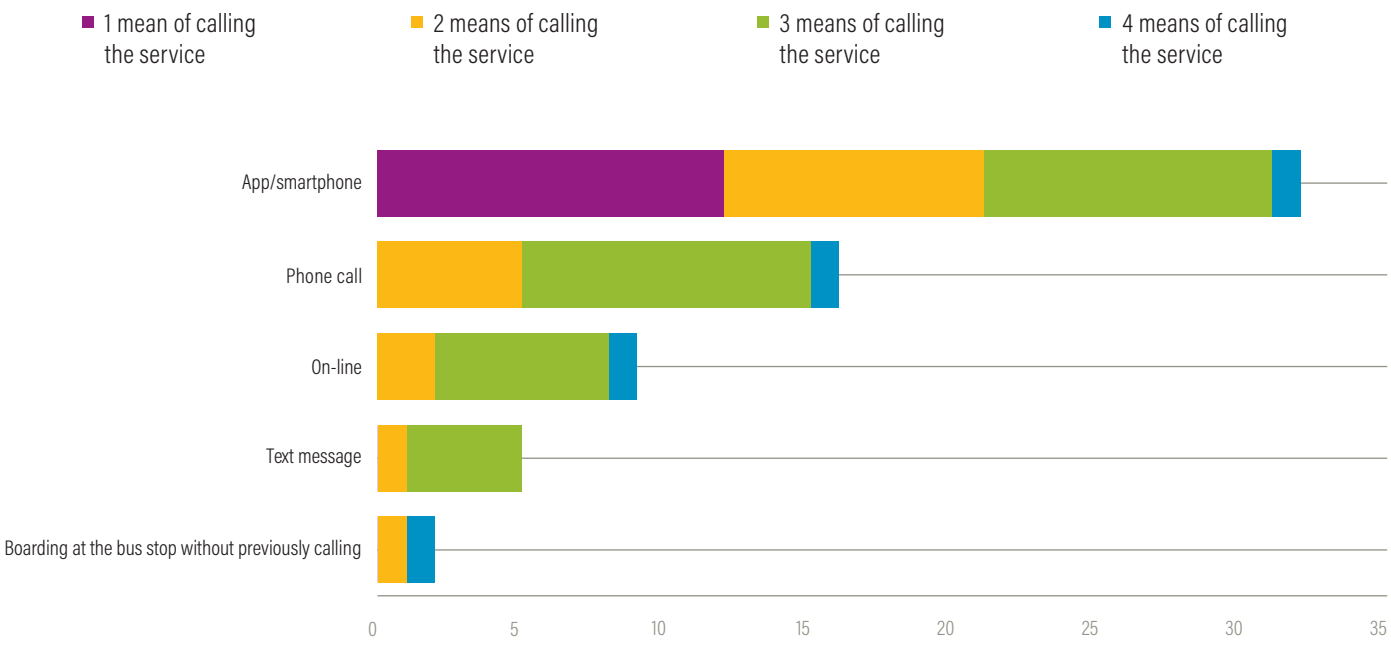
As noted, starting with the first paratransit systems, DRTs that came before the technological advances provided by smartphones used simple routing and scheduling programs to match origins and destinations obtained through the call-and-ride call centers.

DRTs services can now be hailed in many ways. Most involve the use of a cellphone, either via an app, call, or text message. These services can be also requested online without a smartphone, or boarded directly at a bus stop, without advance scheduling.

Figure 24 shows that all cases analyzed (32) include smartphone apps to call the services, with 20 systems combining other means. The second most used method is phone calls (16), which are employed in almost half of the systems, followed by online booking (9).

Although technology has made many advances for DRT systems possible, in Belleville, Canada, bus stop pick-ups are allowed even for passengers without the app or the smartcard. This is an important strategy to allow the social inclusion of those who do not have access to smartphones, especially for countries in the global South, where greater social and economic differences often lead to exclusion from access to transit.

Figure 24 | **DRT system distribution, by hailing method**



Source: Authors, based on dataset 2 (Appendix F).
Note: For this variable, multiple answers were allowed.

Payment Methods

Among the various means of payment that can be used in DRT systems, credit cards (24) and transit system smart cards (12) are the most widely used by operators, followed by cash (11), as shown in Figure 25.

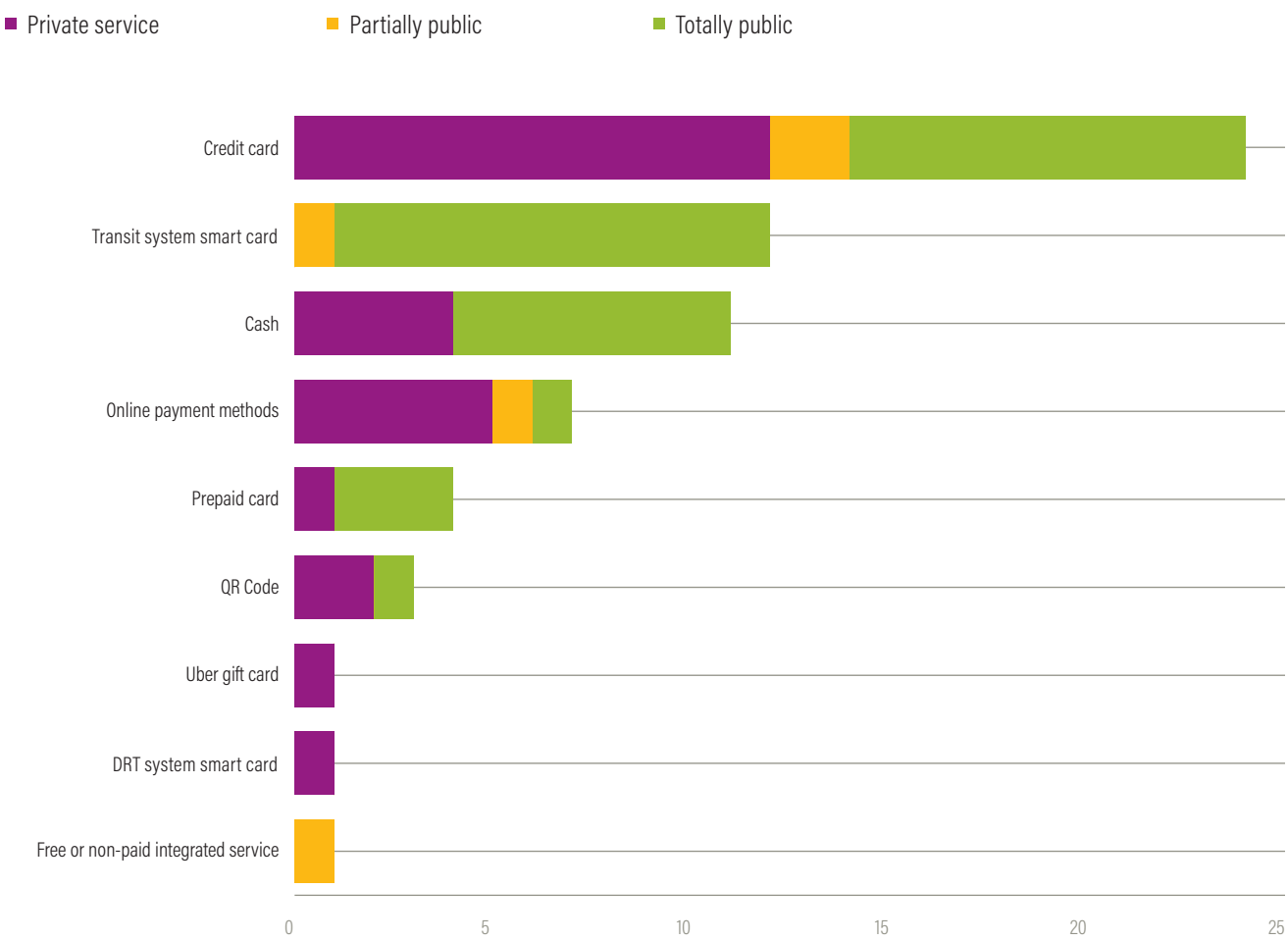
Public-enabled systems (whether partially or fully public) accept credit cards (12) as much as transit system smart cards (12). By contrast, private systems mainly accept the use of credit cards (12) and none have integrated their fares via use of the transit system smart. A few private schemes have found alternative access innovations.

Pricing

DRT pricing varies depending on the fare scheme, and can be set per trip, per route, or variably, defined by an algorithm based on trip length or per zone. It can also be a combination of the above, or free of charge, as is the case with many Paratransit and Corporate/University systems (limited to eligible user groups).

Many services analyzed (13) adopt a fixed fare for any trip, equal to the conventional transit system fare, all of them public, as shown in Figure 26 (next page). Most systems that have fixed fare for any trip, but with prices higher than

Figure 25 | **DRT distribution based on payment methods**

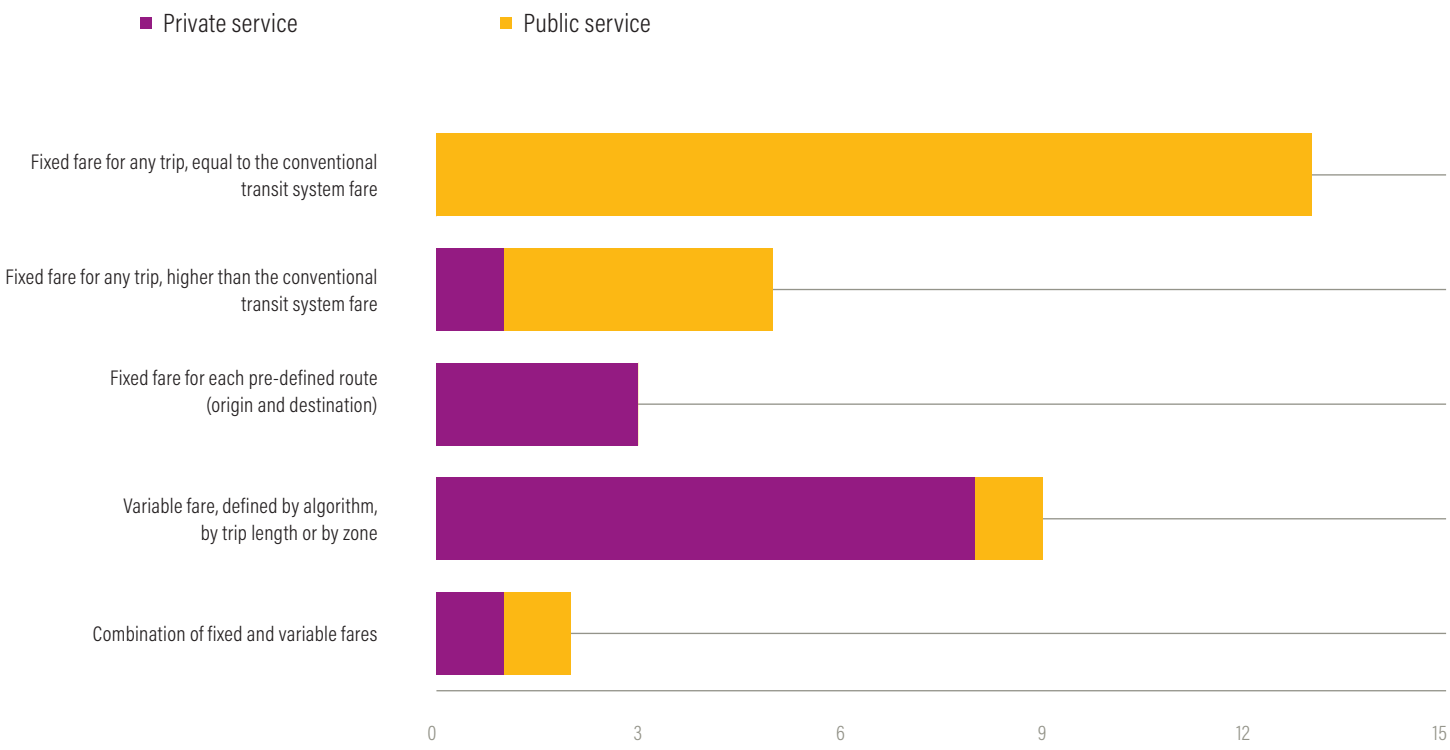


Source: Authors, based on dataset 2 (Appendix F).*Note:* For this variable, multiple answers were allowed. Totally public systems – 15, partially public – 4, private – 13.

the conventional transit system (5), are public, and only one case is a system provided by a private company directly to users.

In turn, fixed fares for pre-defined routes account for three systems, in which all are provided by private services. Algorithm-defined variable fares (9), as well as those using a combination of fixed and variable fares (2), are commonly found in private systems that compete with regular transit, with more flexibility in routes and stops, thus requiring a dynamic pricing scheme.

Figure 26 | **DRT system distribution based on pricing and institutional arrangement**



Source: Authors, based on dataset 2 (Appendix F).
Note: For this variable, multiple answers were allowed.

6. FINAL CONSIDERATIONS

Demand responsive transit services have seen significant growth in recent years, broadly defined, and with a wide diversity of applications and models emerging in several cities on all continents. The present study has the aim to offer an updated definition *(transportation services with some degree of demand responsive route and/or schedule flexibility, operating with transit vehicles (vans, micro-buses, and buses) and IT-based user access on a "as-needed" basis)*; as well as a useful classification scheme and set of attributes.

The relative novelty of the new generation of app-based DRTs has created the need to advance the literature on the subject, especially in developing countries, where there is still limited systematic and comprehensive information. The analysis of cases from various regions and a combination of operational, functional, institutional, and regulatory aspects allowed the identification of clear differences between DRTs in different regional contexts. There is no single model that describes each situation, but it is possible to highlight some common characteristics.

The predominant models of General Public DRT services in high-income countries in Europe, North America, and Australia derive mostly from public policies defined, planned, and regulated by the government. Often conceived in a top-down approach, they are more frequently integrated with the regular public transportation networks.

In developing countries, General Public DRTs appear more as private services aimed at market demand niches. A variety of institutional and legal arrangements can be found, as operational characteristics are also diverse and adapted to each situation. But they all coincide in competing for customers with a range of transport options from public transportation to ride-hailing, private charter buses, cars, and any other potential users willing to migrate to an attractive and cost-effective alternative.

Regarding operational attributes, we found great variety in terms of flexibility in routes, stops, and scheduling. The more flexible DRT operations are, the more they resemble ride-hailing, with a much more real-time demand-responsiveness. Itineraries, boarding, and alighting are defined by optimization software, operating freely without predefined routes.

As for the institutional and regulatory aspects, we found some similarities with ride-hailing companies, where the app manager does not normally own the fleet or hire the drivers, acting only as a "match-maker" between supply and demand. However, unlike ride-hailing models where drivers are mostly individual autonomous workers, in DRTs, the technology providers generally enter partnerships with bus operator companies, which are then responsible for hiring drivers and acquiring the fleet.

Even when not resulting from public policy decisions, DRT services are generally regulated to some extent by the government, either at the local, regional, or national level. When not seen as part of the regular public transportation services, different solutions have been found to classify DRTs within ride-hailing regulation. This can take the form of added benefits from operators of existing concessions or other ways that allow their normal operation, depending on each situation and context. Regarding business models, certain companies operate more than one DRT type, including a fusion of private services for the general public, systems integrated with public transport, corporate services, and even services not responsive to individual trips. These companies use the demand-responsiveness principle to develop technologies, operations, administrative capacity, and market presence to diversify into potentially applicable new sectors and services.

As DRTs continue to evolve, adapting to users' needs and offering options to increase efficiency in situations where regular public transport systems are more costly, new developments will arise. While this working paper sought to provide a starting point for understanding DRTs, the current necessity of expanding the knowledge base on the subject will grow even more, as new questions emerge:

- Decision-makers need more technical knowledge to design and plan the implementation of DRTs. It is useful to generate a benchmark of DRT systems' characteristics, as other modes of transport are better understood in terms of their basic technical characteristics, such as user capacity ranges, performance measures for vehicles and systems, and investment ranges.

- Legal and financial implementation mechanisms vary greatly from place to place. These aspects could also be the subject of analysis and compilation in a benchmark format, for allowing a better understanding of business models and institutional organization. There is a need to explore the potential of DRTs with smaller local operators and not only solutions depending on multinational companies.

- Information on the implementation results of DRT systems is still scarce. Specific analysis of case studies to monitor and evaluate their impacts would be valuable. This kind of study would also contribute to more in-depth knowledge for all parties interested in exploring the potential of DRTs as a valuable option for sustainable mobility in cities and one means of achieving the desired modal shift away from individual transportation.

APPENDIX A: METHOLODOGY SUMMARY

This study's methodology consisted of the collection, consolidation, systematization and analysis of separate sets of information that allowed us to propose a DRT classification based upon the implemented cases. Figure 27 provides a schematic representation of the key activities. The appendices provide information on the data gathered.

1. **Literature review and identification of key attributes** of interest for analysis (appendix 1).

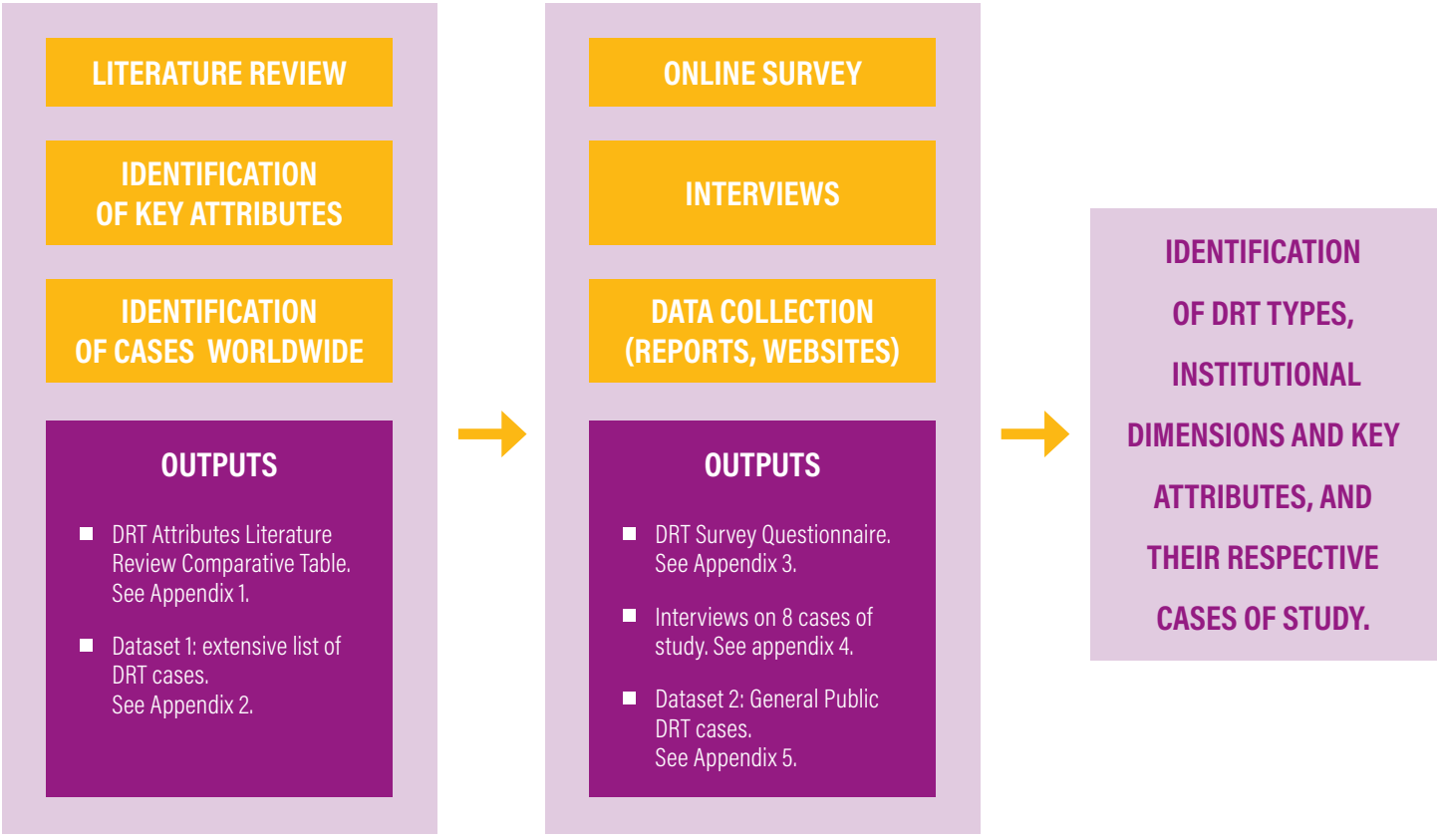
2. The **identification of cases worldwide** (dataset 1, appendix 2) consists on the review and selection of demand-responsive transportation cases. This list does not intend to catalogue all existing systems, but rather to capture the diversity of services, geographical contexts, and their characteristics. In all, 151 cases that satisfied the general DRT definition we adopted, were identified in 23 countries on five continents.

3. An **online survey** (appendix 3) focusing on general public services allowed the gathering of more detailed data about key attributes, which, when merged with a supplementary data collection, resulted in the dataset 2 of 32 cases of General Public DRT (appendix 5).

4. From this process, **interviews** on 8 selected cases (appendix 4) were conducted to deeper understand some issues that go beyond the survey, such as qualitative aspects and lessons learned that are highlighted in specific boxes throughout this report.

5. Other activities consist in the research of supplementary **data collection**, data consolidation, analysis, and systematization of the information gathered. The result is the definition and classification of DRT system types, a set of 9 key attributes and related cases of study in different geographies.

Figure 27 | **Schematic summary of study methodology**



Source: Authors.

APPENDIX B: DRT ATTRIBUTES LITERATURE REVIEW COMPARATIVE TABLE

The literature review provided different approaches to the most relevant features to characterize DRTs. Table 3 shows a comparative table of the attributes examined in the main four references for that purpose.

Table 3 | **DRTs attributes literature review comparative table**

DENMARK (2012)	INTERREG EUROPE (2018)	INSTITUTION OF MECHANICAL ENGINEERS, AND COMMUNITY TRANSPORT ASSOCIATION (CTA) (2018)	PETTERSSON (2019)
Routing	Route	Routing ■ Fully set, but only runs when there is demand ■ Deviations possible within a set corridor ■ Fully flexible	Routing ■ Free floating within a continuous area ■ Fixed destination or origin ■ Combination of free floating and fixed destination or origin ■ Zone-to-zone structure
Stopping points	Stops	Pick-up/drop-off points ■ Many-to-many ■ One-to-many/many-to-one ■ One-to-one	Pick-up/drop-off points ■ Virtual stops ■ Physical stops ■ Combinations
Vehicles	Vehicles	Vehicle ■ Car ■ Minibus ■ Bus	Vehicles and fleet sizes
Bookings	Booking	Booking method ■ Telephone call ■ Internet (website/app)	Booking method
Passengers	Users	Main users ■ All public ■ Disadvantaged groups ■ Private groups	
Fares		Price ■ Free ■ Paid	Pricing
Operators		System financing ■ Subsidized ■ Partly-subsidized ■ Commercial	Service partnerships
	Payment		Payment methods
		Operating hours ■ Only when requested ■ Set number of journeys per day	Operating hours

DENMARK (2012)	INTERREG EUROPE (2018)	INSTITUTION OF MECHANICAL ENGINEERS, AND COMMUNITY TRANSPORT ASSOCIATION (CTA) (2018)	PETTERSSON (2019)
		Time of booking ■ On the day/when required ■ In advance ■ Repeating booking	Time of booking
		Covering area ■ Rural ■ Suburbs ■ Mixed	
		Competition with other transport solutions ■ High ■ Low	

Source: Authors.

Additionally, we present here a set of complementary questions and issues that were raised by the research team during the initial stages of the present work, considered useful for understanding DRTs:

- Is the DRT service targeted at or limited to specific demand segments, niche market or to some specific types of users?
- Is there any kind of physical, operational or fare integration with the regular public transport system?
- Does the DRT play a feeder role for the regular public transport system?
- Institutional model (public/private service provision)
- Is there a DRT specific regulation?
- Was there any pilot implementation?
- Does the fare revenue cover all costs?
- Main actors and roles that were involved in the DRT service provision
- Main barriers and difficulties faced during the implementation process and during the regular or commercial operation phase
- Main lessons learned during the implementation and during the regular or commercial operation phase
- Features and customer services available for users
- Data availability/openness level

These attributes, questions and issues were narrowed to the aspects presented in the study but are registered here in case researchers may find them useful in the future.

APPENDIX C: DATASET 1: EXTENSIVE LIST OF DRT CASES

The list of DRT cases presented in Table 4 was gathered between December 2019 and July 2020. It consists of an extensive but not exhaustive list of 151 cases, developed to map systems self-identified as demand responsive transit. It is not intended to be complete and is a snapshot of the time of study, but rather a starting point for the identification of services for this study, as well as an illustrative (large but not systematic nor representative) sample of the geographic distribution of DRTs around the world. Also, DRT systems have been evolving and changing rather quickly, so it is a dated record. The broad classification of the service included in this table was based on a simplification of the classification typologies presented in the report, also being subject to a considerable degree of uncertainty and imprecision given the scarce and dispersed sources of information found about each one, in many cases possibly out of date.

Table 4 | **List of identified cases of DRT services**

	REGION	COUNTRY	CITY OF REFERENCE	SYSTEM NAME	TYPE OF SERVICE
1	Africa	Egypt	Cairo	Careem Bus	General Public
2	Africa	Egypt	Cairo	UberBus	General Public
3	Asia	Bangladesh	Dhaka	Pipeep	General Public
4	Asia	India	Bengaluru	ZipGo	General Public
5	Asia	India	Chenai	Shuttl	General Public
6	Asia	India	Delhi-NCR	Shuttl	General Public
7	Asia	India	Hyderabad	Easy Commute	General Public
8	Asia	India	Hyderabad	Shuttl	General Public
9	Asia	India	Kolkata	Shuttl	General Public
10	Asia	India	Mumbai	Cityflo	Combination or others
11	Asia	India	Mumbai	Kruze	General Public
12	Asia	India	Mumbai	Mahindra & Mahindra (Glyd)	General Public
13	Asia	India	Mumbai	Shuttl	General Public
14	Asia	India	Pune	Office Ride	Specific Demand Segments
15	Asia	India	Pune	Shuttl	General Public
16	Asia	Indonesia	Jakarta	Bussr	General Public
17	Asia	Indonesia	Bekasi	TRON	General Public
18	Asia	Israel	Tel Aviv	bubble Dan	General Public
19	Asia	Japan	Fukuoka	KnowRoute	General Public
20	Asia	Japan	Tokyo	HillsVia	Specific Demand Segments
21	Asia	Singapore	Singapore	On-Demand Public Bus Trial	General Public
22	Asia	Singapore	Singapore	RushOwl	General Public
23	Asia	Singapore	Singapore (Joo Koon)	BusGo	General Public
24	Asia	United Arab Emirates	Dubai	Careem Bus	Combination or others
25	Europe	England	Essex	Shotl	Specific Demand Segments
26	Europe	England	Kent	ArrivaClick	Specific Demand Segments
27	Europe	England	Leicester	ArrivaClick	General Public
28	Europe	England	Liverpool	ArrivaClick	General Public
29	Europe	England	London	Go Sutton	General Public

	REGION	COUNTRY	CITY OF REFERENCE	SYSTEM NAME	TYPE OF SERVICE
30	Europe	England	London	ViaVan	General Public
31	Europe	England	Milton Keynes	ViaVan	General Public
32	Europe	England	Oxford	PickMeUp	General Public
33	Europe	England	Sittingbourne	ArrivaClick	General Public
34	Europe	Finland	Helsinki	Kutsuplus	General Public
35	Europe	France	Beauvais	Chronopro	General Public
36	Europe	France	Bordeaux	KE'OP	General Public
37	Europe	France	Chelles	LaNavette	Combination or others
38	Europe	France	Cherbourg	Mobilités Cotentin	General Public
39	Europe	France	Clamart	Clam'Express	General Public
40	Europe	France	Courtaboeuf	Chronopro	General Public
41	Europe	France	Lille	Ilévia Réservation	General Public
42	Europe	France	Lyon	TCL à la demande	General Public
43	Europe	France	Marne-la-Vallée	Plus de Pep's	Combination or others
44	Europe	France	Mulhouse	Chronopro	General Public
45	Europe	France	Orléans	Transport à la demande	General Public
46	Europe	France	Orléans	Résa'Tao	General Public
47	Europe	France	Paris (Île-de-France)	Flexigo	Combination or others
48	Europe	France	Paris (Île-de-France)	Transport à la demande	Combination or others
49	Europe	France	Sophia Antipoles	Envibus	Specific Demand Segments
50	Europe	France	Strasbourg	Flex'hop	Combination or others
51	Europe	France	Vitrolles	Chronopro	General Public
52	Europe	Germany	Berlin	BerlKönig	General Public
53	Europe	Germany	Berlin	KVV MyShuttle	General Public
54	Europe	Germany	Bielefeld	ViaVan	Combination or others
55	Europe	Germany	Brandenburg	ViaVan	General Public
56	Europe	Germany	Ludwigshafen	Standort Shuttle Ludwigshafen	Specific Demand Segments
57	Europe	Germany	Vechta	Moobli+	Combination or others
58	Europe	Iceland	Reykjavik	Strætó	Combination or others
59	Europe	Italy	Padua	Nightbus	Specific Demand Segments
60	Europe	Luxembourg	Luxemburgo City	Kussbus	General Public
61	Europe	Netherlands	Amsterdam	ViaVan	General Public
62	Europe	Norway	Sauda	HentMeg	General Public
63	Europe	Poland	Szczecin	Transladem	Combination or others
64	Europe	Portugal	Medio Tejo	Transladem	Combination or others
65	Europe	Spain	Ayuntamiento de Vitoria-Gasteiz	BUX	Combination or others
66	Europe	Spain	Barcelona	El Meu Bus	General Public

	REGION	COUNTRY	CITY OF REFERENCE	SYSTEM NAME	TYPE OF SERVICE
67	Europe	Spain	Castilla y León Region	GMV Transporte a la Demanda (Translademd)	Combination or others
68	Europe	Spain	Madrid	Smart Bus Madrid	Combination or others
69	Europe	Spain	Madrid	Translademd	Combination or others
70	Europe	Spain	Molina de Aragón	Translademd	Combination or others
71	Europe	Spain	Sant Cugat del Valles	Shotl	General Public
72	Europe	Spain	Valencia	CridaBUS	Specific Demand Segments
73	Latin America	Brazil	Florianópolis	4Bus	Specific Demand Segments
74	Latin America	Brazil	Fortaleza	TopBus+	General Public
75	Latin America	Brazil	Goiânia	CityBus 2.0	General Public
76	Latin America	Brazil	São Bernardo do Campo	Ubus	General Public
77	Latin America	Brazil	São Paulo	Atende+	Specific Demand Segments
78	Latin America	Brazil	São Paulo	Buser	Specific Demand Segments
79	Latin America	Colombia	Bogotá	Bussi	Combination or others
80	Latin America	Mexico	Mexico City	Bussi	General Public
81	Latin America	Mexico	Mexico City	Jetty	General Public
82	Latin America	Mexico	Mexico City	Urbvan	General Public
83	Latin America	Mexico	Monterrey	Bussi	Specific Demand Segments
84	Oceania	Australia	Barossa Valley (South Australia)	Keoride	Specific Demand Segments
85	Oceania	Australia	Central Coast	Coast Connect	General Public
86	Oceania	Australia	Central West and Orana	LiveBetter	Specific Demand Segments
87	Oceania	Australia	Central West and Orana	Orana On Demand service	Specific Demand Segments
88	Oceania	Australia	Coffs Harbour (North Coast)	Woopi Connect	Specific Demand Segments
89	Oceania	Australia	Lake Macquarie	Lake Macquarie On Demand Service	General Public
90	Oceania	Australia	Moree (New England North West)	Moree On Demand Bus Service	Specific Demand Segments
91	Oceania	Australia	Mount Barker (South Australia)	Keoride	General Public

	REGION	COUNTRY	CITY OF REFERENCE	SYSTEM NAME	TYPE OF SERVICE
92	Oceania	Australia	Newcastle	Newcastle On Demand services	General Public
93	Oceania	Australia	Northern Rivers	B-ConX	Combination or others
94	Oceania	Australia	Queensland (Logan suburbs)	MyDRTLogan	General Public
95	Oceania	Australia	Riverina Murray region	On Demand Services for the Riverina Murray Region (Albury, Burrumbottock, Walla Walla and Jindera)	Combination or others
96	Oceania	Australia	Riverina Murray region	On Demand Services for the Riverina Murray Region (Holbrook)	Combination or others
97	Oceania	Australia	Sapphire Coast	Flexibus	Combination or others
98	Oceania	Australia	South Coast to Canberra	Rixons	Specific Demand Segments
99	Oceania	Australia	Sydney (Bays Precint)	On Demand Ferry	General Public
100	Oceania	Australia	Sydney (Inner West)	BRIDJ (Transit Systems NSW)	General Public
101	Oceania	Australia	Sydney (North West)	Norwest	General Public
102	Oceania	Australia	Sydney (North West)	The Ponds	General Public
103	Oceania	Australia	Sydney (Northern Beaches)	Keoride	General Public
104	Oceania	Australia	Sydney (NSW)	OurBus	Combination or others
105	Oceania	Australia	Sydney (South and South West)	Edmondson Park	General Public
106	Oceania	New Zealand	Auckland	AT Local	Combination or others
107	Oceania	New Zealand	Timaru	MyWay	General Public
108	USA & Canada	Canada	Belleville	City of Belleville On-Demand Transit	Combination or others
109	USA & Canada	Canada	Innisfil	Innisfil Transit: Powered by Uber	General Public
110	USA & Canada	USA	Alameda–Contra Costa	AC Transit Flex	General Public
111	USA & Canada	USA	Arlington	Arlington on Demand	General Public
112	USA & Canada	USA	Austin	Pickup	General Public
113	USA & Canada	USA	Bakersfield	RYDE	General Public
114	USA & Canada	USA	Bexar County (Texas)	VIA Link	General Public
115	USA & Canada	USA	Boston	On-Demand Paratransit	Specific Demand Segments
116	USA & Canada	USA	Central Florida	ACCESS LYNX	Specific Demand Segments

	REGION	COUNTRY	CITY OF REFERENCE	SYSTEM NAME	TYPE OF SERVICE
117	USA & Canada	USA	Chicago	Pace On Demand	General Public
118	USA & Canada	USA	Dallas Area	DART GoLink	General Public
119	USA & Canada	USA	Denver District	FlexRide	General Public
120	USA & Canada	USA	Des Moines Area	Flex Connect	General Public
121	USA & Canada	USA	Greater Dayton	RTA Connect	General Public
122	USA & Canada	USA	Hillsborough Area	HyperLINK	General Public
123	USA & Canada	USA	Houston	METRO curb2curb	Combination or others
124	USA & Canada	USA	Kansas City	RideKC Freedom	Combination or others
125	USA & Canada	USA	Kitsap	ACCESS	Specific Demand Segments
126	USA & Canada	USA	Los Angeles County	LA Metro Mobility on Demand Pilot	General Public
127	USA & Canada	USA	Los Angeles	RideCo	General Public
128	USA & Canada	USA	Maryland Transit Administration	MobilityLink	Specific Demand Segments
129	USA & Canada	USA	Miami	FreeBee	Combination or others
130	USA & Canada	USA	Michigan	Rapid On Demand	Specific Demand Segments
131	USA & Canada	USA	Monterey–Salinas	MST On Call	Combination or others
132	USA & Canada	USA	Napa Valley	VineGo	Specific Demand Segments
133	USA & Canada	USA	New York	LGA Connect	Specific Demand Segments
134	USA & Canada	USA	New York	Via	General Public
135	USA & Canada	USA	New York	Via for Schools	Specific Demand Segments
136	USA & Canada	USA	New York	Via Georgetown	General Public
137	USA & Canada	USA	North County	FLEX	General Public
138	USA & Canada	USA	Orange County	OC Flex	General Public

	REGION	COUNTRY	CITY OF REFERENCE	SYSTEM NAME	TYPE OF SERVICE
139	USA & Canada	USA	Rogers	On-Demand Transit	General Public
140	USA & Canada	USA	Sacramento	SmaRT Ride	General Public
141	USA & Canada	USA	Salem–Keizer	Connector	Combination or others
142	USA & Canada	USA	San Francisco	SamTrans OnDemand	Combination or others
143	USA & Canada	USA	San Joaquin	RTD GO!	General Public
144	USA & Canada	USA	San José	VTA Flex	General Public
145	USA & Canada	USA	Seattle	Via to Transit	General Public
146	USA & Canada	USA	Snellville	TransLoc	General Public
147	USA & Canada	USA	Southern Nevada (state)	Trip to Strip!	Combination or others
148	USA & Canada	USA	Utah (state)	UTA On Demand	General Public
149	USA & Canada	USA	Vermont (state)	Transit App	General Public
150	USA & Canada	USA	Washington, D.C	Ride On Flex	General Public
151	USA & Canada	USA	West Sacramento	West Sacramento On-Demand	Combination or others

Source: Authors.

APPENDIX D: DRT SURVEY QUESTIONNAIRE

Section 1/4: General Information

1. What is the name of the Demand Responsive Transit (DRT) system you will describe in this survey?

2. Country

3. City

4. What is the role of the organization you belong to in this DRT?
(check all that apply)
   - ☐ Technology provider/app manager
   - ☐ Transport service provider/vehicle operator company
   - ☐ Regulator/public sector contractor
   - ☐ Other role in the service provision system
   - ☐ User
   - ☐ Other:

5. When did the DRT service begin to operate in the city?
(approximate date)

6. What area does your service cover?
(mark only one option)
   - ☐ Whole country
   - ☐ Whole state (or sub-national subdivision)
   - ☐ Metropolitan region
   - ☐ City
   - ☐ District (city subdivision)
   - ☐ Neighborhood
   - ☐ Within a private establishment or controlled access perimeter
   - ☐ Specific corridors (conexions between specific origins and destinations)
   - ☐ Other:

7. What types of vehicle operate in the DRT service?
(mark all that apply)
   - ☐ Vans
   - ☐ Microbuses
   - ☐ Conventional Buses
   - ☐ Other:

8. Please indicate: the total number of registered users; the number of male users; and the number of female users.

Section 2/4: Service provision

9. How flexible are the routes?
(mark only one option)
   - ☐ Predefined fixed routes (no changes on itinerary allowed)
   - ☐ Predefined flexible routes (fixed origin and destination, but flexible itinerary)
   - ☐ No predefined routes, but operating within predefined areas or perimeters
   - ☐ Citywide services with no predefined routes (journeys completely defined for each trip)
   - ☐ Other:

10. Means of calling/accessing the service:
(check all that apply)
    - ☐ App/smartphone
    - ☐ On-line
    - ☐ Totem
    - ☐ Phone call
    - ☐ Text message
    - ☐ Boarding at the bus stop without previously calling
    - ☐ Other:

11. Payment methods available:
(check all that apply)
    - ☐ Credit Card
    - ☐ Cash
    - ☐ Transit System Smart Card
    - ☐ DRT System Smart Card
    - ☐ On-line payment methods
    - ☐ QR Code
    - ☐ Other:

12. How is the price of a DRT trip set?
(mark only one option)
    - ☐ Fixed fare for any trip, equal to the conventional transit system fare
    - ☐ Fixed fare for any trip, higher than the conventional transit system fare
    - ☐ Fixed fare for each pre-defined route (origin and destination)
    - ☐ Variable fare, defined by algorithm, by trip length or by zone
    - ☐ Other:

13. What is the DRT operation model in terms of public/private service provision?
(mark only one option)
    - ☐ Not regulated private service (DRT offered by a private company directly to users, with no DRT specific regulatory framework)
    - ☐ Regulated private service (DRT offered by a private company directly to users, with no participation or intermediation of a public authority but under a DRT specific regulatory framework)
    - ☐ Totally public (DRT fully integrated with the city's public transport system)
    - ☐ Partially public (DRT is a private service with some level of integration with the city's public transport system)
    - ☐ Other:

14. Who hires the technology provider or app manager?
(mark only one option)
    - ☐ App manager hired by the public sector or the city's transit agency
    - ☐ App manager hired by a bus operating company
    - ☐ App manager provides service directly to users, with no partnerships with third parties (either from public or private sectors)
    - ☐ Other:

Section 3/4: Actors involved in the service provision

Indicate who the following stakeholders are in the DRT system: vehicle operators; technology provider (app manager); contractor; regulator agency; other important agents. Please complete all main stakeholders involved in the service provision.

For each role, please provide name and type of organization (public sector institution, private company, NGO, individuals, etc.). If a stakeholder plays more than one role in the service provision, please mention it explicitly.

15. Technology provider (app manager):

16. Vehicle operator(s):

17. Regulator/Public Authority (if applicable):

18. Other role (describe):

19. Other role (describe):

20. Other role (describe):

Section 4/4: Complementary questions (optional)

21. Does the DRT service play a feeder role for the city's public transport system (first/last mile)? If yes, please describe.

22. Is there any kind of integration with the conventional public transport system? If there is fare integration, what is the discount compared to the full fare? How does it work?

23. If there is any regulation dealing explicitly or specifically with DRT services, could you provide a reference to find it or describe it in a few words? If possible, clarify if it is a local or national regulation.

APPENDIX E: INTERVIEWS

Table 5 | **List of interviews**

COUNTRY	CITIES	SYSTEM	INTERVIEWEE	ROLE
Australia	Sydney	Inner West On Demand service	BRIDJ (John Langford-Ely)	Technology provider
Brazil	Fortaleza	TopBus+	ETUFOR (Antônio Ferreira Silva)	Public sector
Brazil	Goiania and Fortaleza	TopBus+ and CityBus 2.0	Via Brasil (Leandro Aliseda)	Technology provider
Brazil	São Paulo	Atende+	SPTrans (José Biagioni)	Public sector
France	Strasbourg	Flex'Hop	PADAM (Lucas Cinelli)	Technology provider
India	Delhi NCR, Kolkata, Hyderabad, Pune, Mumbai, and Chennai	Shuttl	Shuttl (Manish Pandey, Vishwas Singh, Vibhor Juyal)	Technology provider
India	Mumbai	CityFlo	CityFlo (Rushabh Shah)	Technology provider
Mexico	Mexico City	Jetty	Jetty (Onesimo Flores)	Technology provider
Singapore	Singapore	On Demand Public Bus Trial	LTA (Jelphine Goh)	Public sector
			Alok Jain	DRT expert

Source: Authors.

APPENDIX F: DATASET 2: GENERAL PUBLIC DRT CASES

The dataset of DRT cases presented from Table 6 to Table 9 contains the information collected and systematized for the 32 General Public DRT systems used in this study. It was elaborated from the survey (appendix D) and supplementary information collected in publicly available sources, with data gathered and treated between December 2019 and July 2020.

Table 6 | **Dataset of General Public DRT systems (General systems' information)**

DRT SYSTEM	CITY OF REFERENCE	COUNTRY	DEVELOPMENT	REGION	MAIN SOURCE	TYPE OF SERVICE	OPENING DATE	OPERATING/ CLOSED BY APRIL 2020
Careem Bus	Cairo	Egypt	Developing	Africa	survey	General Public	dec/2018	not operating
UberBus	Cairo	Egypt	Developing	Africa	info online	General Public	dec/2018	operating
Shuttl	Delhi NCR	India	Developing	Asia	survey	General Public	apr/2015	operating
TRON	Bekasi	Indonesia	Developing	Asia	info online	General Public	apr/2019	operating
bubble Dan	Tel Aviv	Israel	Developed	Asia	survey	General Public	apr/2019	operating
On-Demand Public Bus Trial	Singapore	Singapore	Developed	Asia	survey	General Public	dec/2018	pilot already ended
Careem Bus	Dubai	United Arab Emirates	Developed	Asia	info online	General Public	may/2019	operating
ArrivaClick	Liverpool	England	Developed	Europe	survey	General Public	aug/2018	operating
Go Sutton	London	England	Developed	Europe	info online	General Public	may/2019	pilot already ended
PickMeUp	Oxford	England	Developed	Europe	survey	General Public	june/2018	operating
Kutsuplus	Helsinki	Finland	Developed	Europe	info online	General Public	oct/2012	pilot already ended
Transport à la demande	Orléans	France	Developed	Europe	survey	General Public	nov/2018	operating
Résa'Tao	Orléans	France	Developed	Europe	survey	General Public	apr/2018	operating
Transport à la demande	Paris (Île-de-France)	France	Developed	Europe	info online	General Public	not available	operating
Flex'hop	Strasbourg	France	Developed	Europe	survey	General Public	sept/2019	operating

DRT SYSTEM	CITY OF REFERENCE	COUNTRY	DEVELOPMENT	REGION	MAIN SOURCE	TYPE OF SERVICE	OPENING DATE	OPERATING/ CLOSED BY APRIL 2020
ViaVan	Amsterdam	Netherlands	Developed	Europe	info online	General Public	not available	operating
Shotl	Sant Cugat del Valles	Spain	Developed	Europe	survey	General Public	july/2017	operating
TopBus+	Fortaleza	Brazil	Developing	Latin America	survey	General Public	dec/2019	operating
CityBus 2.0	Goiânia	Brazil	Developing	Latin America	survey	General Public	feb/2019	operating
Bussi	Mexico City	Mexico	Developing	Latin America	survey	General Public	aug/2017	operating
Jetty	Mexico City	Mexico	Developing	Latin America	survey	General Public	aug/2017	operating
Urbvan	Mexico City	Mexico	Developing	Latin America	survey	General Public	jan/2017	operating
BRIDJ	Sydney	Australia	Developed	Oceania	survey	General Public	nov/2017	operating
Keoride	Sydney	Australia	Developed	Oceania	survey	General Public	nov/2017	operating
City of Belleville On-Demand Transit	Belleville	Canada	Developed	USA & Canada	survey	General Public	sept/2018	operating
Innisfil Transit: Powered by Uber	Town of Innisfil	Canada	Developed	USA & Canada	survey	General Public	may/2017	not operating
Arlington on Demand	Arlington	USA	Developed	USA & Canada	survey	General Public	dec/2017	operating
DART GoLink	Dallas Area	USA	Developed	USA & Canada	survey	General Public	sept/2017	operating
LA Metro Mobility on Demand Pilot	Los Angeles County	USA	Developed	USA & Canada	survey	General Public	jan/2019	operating pilot
SmaRT Ride	Sacramento	USA	Developed	USA & Canada	survey	General Public	feb/2018	operating
Via to Transit	Seattle	USA	Developed	USA & Canada	survey	General Public	apr/2019	operating pilot
West Sacramento On-Demand	West Sacramento	USA	Developed	USA & Canada	survey	General Public	may/2018	operating

Source: Authors.

Table 7 | **Dataset of General Public DRT systems (geographic coverage; vehicles types; route flexibility; booking method; and payment methods comparison)**

DRT SYSTEM	GEOGRAPHIC COVERAGE	VEHICLE TYPES	ROUTE FLEXIBILITY	BOOKING METHOD	PAYMENT METHODS
Careem Bus-Cairo	City	Microbuses	Predefined fixed routes (no changes on itinerary allowed)	App/smartphone	Credit Card, Cash
UberBus-Cairo	City	Mini Van	Predefined fixed routes (no changes on itinerary allowed)	App/smartphone	Credit Card, Cash
Shuttl-Delhi NCR	Metropolitan region	Conventional Buses	Predefined fixed routes (no changes on itinerary allowed)	App/smartphone	Credit Card, On-line payment methods
TRON-Bekasi	Specific corridors	Vans	Predefined flexible routes (fixed origin and destination, but flexible itinerary)	App/smartphone	Credit Card, On-line payment methods
bubble Dan-Tel Aviv	Metropolitan region	Vans	Citywide services with no predefined routes	App/smartphone, text message	Credit Card
On-Demand Public Bus Trial-Singapore	Neighborhood/ District	Conventional Buses	No predefined routes, but operating within predefined areas or perimeters	App/smartphone	Credit Card, Cash, Transit System Smart Card
Careem Bus-Dubai	Specific corridors	Microbuses	Predefined fixed routes (no changes on itinerary allowed)	App/smartphone	Cash
ArrivaClick-Liverpool	City	Vans	No predefined routes, but operating within predefined areas or perimeters	App/smartphone	Credit Card
Go Sutton-London	Neighborhood/ District	Vans	No predefined routes, but operating within predefined areas or perimeters	App/smartphone, phone call, text message	Credit Card, Free pass cards
PickMeUp-Oxford	City	Vans	No predefined routes, but operating within predefined areas or perimeters	App/smartphone	Credit Card
Kutsuplus-Helsinki	Metropolitan region	Microbuses	No predefined routes, but operating within predefined areas or perimeters	App/smartphone, On-line	Credit Card, On-line payment methods
Transport à la demande-Orléans	Metropolitan region	Vans	No predefined routes, but operating within predefined areas or perimeters	App/smartphone, On-line, phone call	Transit System Smart Card
Résa'Tao-Orléans	Metropolitan region	Vans	No predefined routes, but operating within predefined areas or perimeters	App/smartphone, On-line, phone call	Cash, Transit System Smart Card
Transport à la demande-Paris (Île-de-France)	Metropolitan region	Microbuses	Predefined flexible routes (fixed origin and destination, but flexible itinerary)	App/smartphone, On-line, phone call	Transit System Smart Card
Flex'hop-Strasbourg	Neighborhood/ District	Vans	No predefined routes, but operating within predefined areas or perimeters	App/smartphone, On-line, phone call	Cash, Transit System Smart Card
ViaVan-Amsterdam	Metropolitan region	Mini Van	No predefined routes, but operating within predefined areas or perimeters	App/smartphone	Credit Card, DRT System Smart Card, On-line payment methods
Shotl-Sant Cugat del Valles	Neighborhood/ District	Microbuses	No predefined routes, but operating within predefined areas or perimeters	App/smartphone, phone call	Cash, Transit System Smart Card, in-app payment with credit card
TopBus+ - Fortaleza	City	Vans	No predefined routes, but operating within predefined areas or perimeters	App/smartphone	Credit Card

DRT SYSTEM	GEOGRAPHIC COVERAGE	VEHICLE TYPES	ROUTE FLEXIBILITY	BOOKING METHOD	PAYMENT METHODS
CityBus 2.0-Goiânia	City	Vans	No predefined routes, but operating within predefined areas or perimeters	App/smartphone	Credit Card, Cash
Bussi-Mexico City	Metropolitan region	Vans	Predefined fixed routes (no changes on itinerary allowed)	App/smartphone, On-line	Credit Card, On-line payment methods, QR Code
Jetty-Mexico City	Metropolitan region	Vans, Microbuses, Conventional Buses (Shared taxis only during initial pilot phase)	Predefined flexible routes (fixed origin and destination, but flexible itinerary)	App/smartphone, boarding at the bus stop without previously calling	Credit Card, On-line payment methods, QR Code, Prepayment (Tap up account in grocery stores)
Urbvan-Mexico City	Metropolitan region	Vans, Micro-buses	Predefined flexible routes (fixed origin and destination, but flexible itinerary)	App/smartphone	Credit Card, On-line payment methods
BRIDJ-Sydney	Neighborhood/ District	Microbuses	No predefined routes, but operating within predefined areas or perimeters	App/smartphone, phone call	Credit Card, Transit System Smart Card
Keoride-Sydney	Neighborhood/ District	Vans	No predefined routes, but operating within predefined areas or perimeters	App/smartphone, phone call	Credit Card, Transit System Smart Card
City of Belleville On-Demand Transit-Belleville	City	Conventional Buses	Citywide services with no predefined routes	App/smartphone, On-line, phone call, boarding at the bus stop without previously calling	Cash, QR Code
Innisfil Transit: Powered by Uber-Town of Innisfil	City	Sedans and minivans of Uber driver partners	Citywide services with no predefined routes	App/smartphone, On-line, phone call	Credit Card, Uber gift card, trips through call-in service can be paid with cash to Town
Arlington on Demand-Arlington	Neighborhood/ District	Vans	No predefined routes, but operating within predefined areas or perimeters	App/smartphone, phone call, text message	Credit Card, Prepaid Card
DART GoLink-Dallas Area	Metropolitan region	Vans, Microbuses	No predefined routes, but operating within predefined areas or perimeters	App/smartphone, phone call	Credit Card, Cash, Transit System Smart Card
LA Metro Mobility on Demand Pilot-Los Angeles County	Specific corridors	Vans, Sedans	No predefined routes, but operating within predefined areas or perimeters	App/smartphone, phone call	Not applicable (free integrated service)
SmaRT Ride-Sacramento	Specific corridors	Microbuses, Conventional Buses	No predefined routes, but operating within predefined areas or perimeters	App/smartphone, On-line, phone call	Cash, Transit System Smart Card
Via to Transit-Seattle	Neighborhood/ District	Vans	No predefined routes, but operating within predefined areas or perimeters	App/smartphone, phone call, text message	Credit Card, Transit System Smart Card, Prepaid Card
West Sacramento On-Demand-West Sacramento	City	Vans	Citywide services with no predefined routes	App/smartphone, phone call, text message	Credit Card, Transit System Smart Card, Prepaid Card

Source: Authors.

Table 8 | **Dataset of General Public DRT systems (pricing; fare integration; and service provision comparison)**

DRT SYSTEM	PRICING	FARE INTEGRATION	FARE INTEGRATION-OBSERVATION	SERVICE PROVISION
Careem Bus-Cairo	Fixed fare for each pre-defined route (origin and destination)	No		Not regulated private service (DRT offered by a private company directly to users, with no DRT specific regulatory framework)
UberBus-Cairo	Variable fare, defined by algorithm, by trip length or by zone	No		Regulated private service (DRT offered by a private company directly to users, with no participation or intermediation of a public authority but under a DRT specific regulatory framework)
Shuttl-Delhi NCR	Fixed fare for any trip, higher than the conventional transit system fare	No		Not regulated private service (DRT offered by a private company directly to users, with no DRT specific regulatory framework)
TRON-Bekasi	Fixed fare for any trip, equal to the conventional transit system fare	Yes		Partially public (DRT is a private service with some level of integration with the city's public transport system)
Bubble Dan-Tel Aviv	Fixed fare for any trip, higher than the conventional transit system fare	No		Totally public (DRT fully integrated with the city's public transport system)
On-Demand Public Bus Trial-Singapore	Fixed fare for any trip, equal to the conventional transit system fare	Yes	As part of the trial, a promotional flat distance fare was applied for travel on the on-demand public bus regardless of the distance travelled. However, distance-fare transfer rules still applied	Totally public (DRT fully integrated with the city's public transport system)
Careem Bus-Dubai	Fixed fare for each pre-defined route (origin and destination)	No		Not regulated private service (DRT offered by a private company directly to users, with no DRT specific regulatory framework)
ArrivaClick-Liverpool	Variable fare, defined by algorithm, by trip length or by zone	No		Not regulated private service (DRT offered by a private company directly to users, with no DRT specific regulatory framework)
Go Sutton-London	Variable fare, defined by algorithm, by trip length or by zone	No		Partially public (DRT is a private service with some level of integration with the city's public transport system)
PickMeUp-Oxford	Variable fare, defined by algorithm, by trip length or by zone	No		Not regulated private service (DRT offered by a private company directly to users, with no DRT specific regulatory framework)
Kutsuplus-Helsinki	Combination of fixed and variable fares	Yes		Totally public (DRT fully integrated with the city's public transport system)

DRT SYSTEM	PRICING	FARE INTEGRATION	FARE INTEGRATION-OBSERVATION	SERVICE PROVISION
Transport à la demande-Orléans	Fixed fare for any trip, equal to the conventional transit system fare	Yes		Totally public (DRT fully integrated with the city's public transport system)
Résa'Tao-Orléans	Fixed fare for any trip, equal to the conventional transit system fare	Yes	Integration to be done with the local trip planner. Fares are the same as in conventional public transport as this DRT is a part of the public offer	Totally public (DRT fully integrated with the city's public transport system)
Transport à la demande-Paris (Île-de-France)	Fixed fare for any trip, equal to the conventional transit system fare	Yes		Partially public (DRT is a private service with some level of integration with the city's public transport system)
Flex'hop-Strasbourg	Fixed fare for any trip, equal to the conventional transit system fare	Yes	A single ticket can be used for DRT and the other transportation types	Totally public (DRT fully integrated with the city's public transport system)
ViaVan-Amsterdam	Variable fare, defined by algorithm, by trip length or by zone	No		Regulated private service (DRT offered by a private company directly to users, with no participation or intermediation of a public authority but under a DRT specific regulatory framework)
Shotl-Sant Cugat del Valles	Fixed fare for any trip, equal to the conventional transit system fare	Yes	There is fare integration, being transfers for free	Totally public (DRT fully integrated with the city's public transport system)
TopBus+ -Fortaleza	Variable fare, defined by algorithm, by trip length or by zone	No	It is being dicussed to integrate with city's smartcard with fare integration	Regulated private service (DRT offered by a private company directly to users, with no participation or intermediation of a public authority but under a DRT specific regulatory framework)
CityBus 2.0-Goiânia	Variable fare, defined by algorithm, by trip length or by zone	Yes	It is being dicussed to integrate with city's smartcard with fare integration	Regulated private service (DRT offered by a private company directly to users, with no participation or intermediation of a public authority but under a DRT specific regulatory framework)
Bussi-Mexico City	Variable fare, defined by algorithm, by trip length or by zone	No	We are looking to close that kind of integrations during this year	Regulated private service (DRT offered by a private company directly to users, with no participation or intermediation of a public authority but under a DRT specific regulatory framework)
Jetty-Mexico City	Fixed fare for each pre-defined route (origin and destination)	No		Regulated private service (DRT offered by a private company directly to users, with no participation or intermediation of a public authority but under a DRT specific regulatory framework)
Urbvan-Mexico City	Variable fare, defined by algorithm, by trip length or by zone	No		Regulated private service (DRT offered by a private company directly to users, with no participation or intermediation of a public authority but under a DRT specific regulatory framework)

DRT SYSTEM	PRICING	FARE INTEGRATION	FARE INTEGRATION-OBSERVATION	SERVICE PROVISION
BRIDJ-Sydney	Fixed fare for any trip, higher than the conventional transit system fare	Yes	Fare integration is coming soon via OpalConnect	Totally public (DRT fully integrated with the city's public transport system)
Keoride-Sydney	Fixed fare for any trip, equal to the conventional transit system fare	Yes	We will soon implement an Opal Connect integration (Opal is the local transit card system)	Totally public (DRT fully integrated with the city's public transport system)
City of Belleville On-Demand Transit-Belleville	Fixed fare for any trip, equal to the conventional transit system fare	Yes	ODT runs after the regular service, and all fares are the same	Totally public (DRT fully integrated with the city's public transport system)
Innisfil Transit: Powered by Uber-Town of Innisfil	Combination of fixed and variable fares	Yes	Plays a feeder role for regional transit system	Regulated private service (DRT offered by a private company directly to users, with no participation or intermediation of a public authority but under a DRT specific regulatory framework)
Arlington on Demand-Arlington	Fixed fare for any trip, higher than the conventional transit system fare	No		Totally public (DRT fully integrated with the city's public transport system)
DART GoLink-Dallas Area	Fixed fare for any trip, equal to the conventional transit system fare	Yes	Completely integrated to the DART GoPass MaaS app	Totally public (DRT fully integrated with the city's public transport system)
LA Metro Mobility on Demand Pilot-Los Angeles County	Fixed fare for any trip, equal to the conventional transit system fare	Yes	It is considered a free transfer. Because the rides are only provided to and from the transit station, there is no payment for the on-demand ride	Partially public (DRT is a private service with some level of integration with the city's public transport system)
SmaRT Ride-Sacramento	Fixed fare for any trip, equal to the conventional transit system fare	Yes	It drops at light rail	Totally public (DRT fully integrated with the city's public transport system)
Via to Transit-Seattle	Fixed fare for any trip, equal to the conventional transit system fare	Yes	Rides count as a free transfer between DRT and fixed route	Totally public (DRT fully integrated with the city's public transport system)
West Sacramento On-Demand-West Sacramento	Fixed fare for any trip, higher than the conventional transit system fare	No		Totally public (DRT fully integrated with the city's public transport system)

Source: Authors.

Table 9 | **Dataset of General Public DRT systems (app manager hirer; app manager; vehicle operator; public authority; and other actors comparison)**

DRT SYSTEM	APP MANAGER HIRER	APP MANAGER	VEHICLE OPERATOR	PUBLIC AUTHORITY	OTHER ACTORS
Careem Bus-Cairo	App manager provides service directly to users, with no partnerships with third parties (either from public or private sectors)	Careem	Many		
UberBus-Cairo	App manager provides service directly to users, with no partnerships with third parties (either from public or private sectors)	Uber	Uber (autonomous drivers)		
Shuttl-Delhi NCR	App manager provides service directly to users, with no partnerships with third parties (either from public or private sectors)	Shuttl (in-house engineering)	Multiple (individuals or fleet operators)	State Transport Department	
TRON-Bekasi	Teknologi Rancang Olah Nusantara (TRON)				
bubble Dan-Tel Aviv	App manager hired by a bus operating company	Via Mobility Israel	United Tours	Ministry of Transportation	Service concessionaire: Dan company for public transportation ltd
On-Demand Public Bus Trial-Singapore	App manager hired by the public sector or the city's transit agency	Via Transportation Inc., Private company and Ministry of Movement Pte. Ltd (SWAT), Private company	SBS Transit Ltd, Public bus operator and SMRT Buses Ltd, Public bus operator	Land Transport Authority	
Careem Bus-Dubai	App manager provides service directly to users, with no partnerships with third parties (either from public or private sectors)	Careem	Many	Saudi Public Transport Authority	
ArrivaClick-Liverpool	App manager hired by a bus operating company	ViaVan	Arriva		
Go Sutton-London	App manager hired by a bus operating company				
PickMeUp-Oxford	App manager hired by a bus operating company	ViaVan	Oxford Bus Company		
Kutsuplus-Helsinki	App manager hired by the public sector or the city's transit agency	Split Finland	Helsinki Regional Transport Authority	Helsinki Regional Transport Authority	
Transport à la demande-Orléans	App manager hired by the public sector or the city's transit agency	Padam Mobility	Keolis Orléans	Orléans Metropole	
Résa'Tao-Orléans	App manager hired by the public sector or the city's transit agency	Padam Mobility https://padam-mobility.com/?lang=en	Kéolis Orléans Val de Loire	Orléans Métropole	

DRT SYSTEM	APP MANAGER HIRER	APP MANAGER	VEHICLE OPERATOR	PUBLIC AUTHORITY	OTHER ACTORS
Transport à la demande-Paris (Île-de-France)	App manager hired by a bus operating company	Padam			
Flex'hop-Strasbourg	App manager hired by a bus operating company	Padam Mobility	Antoni	CTS	
ViaVan-Amsterdam	App manager provides service directly to users, with no partnerships with third parties (either from public or private sectors)	ViaVan (joint venture between Via and Daimler AG)			
Shotl-Sant Cugat del Valles	App manager hired by a bus operating company	Shotl Transportation-https://shotl.com/	Moventis (bus operator)-http://www.moventis.es/es	Sant Cugat City Council-https://www.santcugat.cat/	
TopBus+ - Fortaleza	App manager hired by a bus operating company	Via	Sindionibus	ETUFOR	
CityBus 2.0-Goiânia	App manager hired by a bus operating company	Via	HP Transportes	CMTC	
Bussi-Mexico City	App manager provides service directly to users, with no partnerships with third parties (either from public or private sectors)	BUSSI	Several Operators who want to joing the platform		
Jetty-Mexico City	App manager hired by a bus operating company	Jetty	Many different operators	Semovi CDMX and Semov Edomex	
Urbvan-Mexico City	By multiple bus operating company and individuals	Urbvan	Partners-bus operating company and individual owners	Semovi	
BRIDJ-Sydney	App manager hired by a bus operating company	BRIDJ	Transit Systems	Transport for New South Wales	
Keoride-Sydney		Via	Keolis Downer	Transport for NSW	
City of Belleville On-Demand Transit-Belleville	App manager hired by a bus operating company	Pantonium Inc.	City of Belleville (Belleville Transit)		
Innisfil Transit: Powered by Uber-Town of Innisfil	The Town has contracted/hired Uber to provide transit service	Uber	Uber	Town of Innisfil	Taxi company for wheelchair accessible trips
Arlington on Demand-Arlington	App manager hired by the public sector or the city's transit agency	Via	Via	State of Texas	
DART GoLink-Dallas Area	App manager hired by the public sector or the city's transit agency	Spare (Spare Labs Inc.)	Multiple (brokered system to many operators)	Dallas Area Rapid Transit	

DRT SYSTEM	APP MANAGER HIRER	APP MANAGER	VEHICLE OPERATOR	PUBLIC AUTHORITY	OTHER ACTORS
LA Metro Mobility on Demand Pilot-Los Angeles County	App manager hired by the public sector or the city's transit agency	Via (Nomad Transit LLC)	Via (Nomad Transit LLC)	Los Angeles County Transportation Authority	
SmaRT Ride-Sacramento	App manager hired by the public sector or the city's transit agency	Via (Transloc prior)	SacRT	Public	
Via to Transit-Seattle	App manager hired by the public sector or the city's transit agency	Via	Via	King County Metro	
West Sacramento On-Demand-West Sacramento	App manager hired by the public sector or the city's transit agency	Via	Via	California Public Utilities Commission	

Source: Authors.

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ENDNOTES

1. Although pooled services are also offered in ride-hailing, which are closer to DRTs, this study intents to analyze modes that multiload passengers to the maximum extent possible (Volinski 2019).
2. Some of the cases analyzed use cars as part of their fleet, but always in combination with larger vehicles, like vans, microbuses, and buses.
3. Asia might be underrepresented in this study due to the difficulty on the access of information, specially language.
4. The mentioned literature belong to Kirby et al. (1974), KFH Group (2008), Enoch et al. (2004), Denmark (2012).
5. Trips at night and between cities were considered as specific user groups and thus different service types.
6. This is a snapshot from 2019-2020. The disruption caused by the COVID-19 pandemic in the public transportation sector all over the world, however, may impose changes in the original plans in this case.
7. The precariousness and potential exploitation faced by these drivers is a very important issue but one that falls outside this study's purview.
8. Executive or premium services if managed by the city can fit under the supplementary model.

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ABOUT THE AUTHORS

Germán Freiberg is the Director of REDES Planejamento e Política Pública em Mobilidade Urbana. Contact: german@redesmobilidade.com

Bruna Pizzol is a PhD student in Transportation Engineering from University of São Paulo. Contact: brupizzol@gmail.com

Leonardo Bueno is a PhD candidate in Public Administration at Getúlio Vargas Foundation. Contact: leobueno17@gmail.com

David Escalante is a mexican transportation engineer specialized in sustainable urban mobility planning, implementation and operations. Contact: david.escalante.sanchez@gmail.com

Tania Pérez is Transport Planning and Operation Coordinator at WRI Ross Center for Sustainable Cities. Contact: tania.perez@wri.org

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