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The role of the Bus Rapid Transit in public transport

Abstract: The article familiarizes the reader with the concept of Bus Rapid Transit systems as a type of transport that combines the advantages of conventional buses, tramways and urban rail transit systems. For this purpose, the genesis of the idea of BRT systems was presented and the system functioning in Curitiba, considered to be the progenitor of the concept, was described. In the second part, the advantages and disadvantages of BRT systems as compared with other means of urban transport were described and differences between BRT subtypes, including BRT Lite, Heavy and Full BRT were presented. The final part of the article was devoted to illustrating the process of expansion of BRT systems around the world and the development of these systems in selected countries.

Keywords: BRT; BRT Lite; BRT Heavy; Full BRT; Metro-Bus; BHLS

Introduction

The increase in the share of passenger journeys by city breaks contributes to a decrease in the efficiency of their transport systems.

This problem is faced by both managers and planners and residents of urban areas. One of the possible solutions to improve public transport is Bus Rapid Transit systems, which are currently used around the world. The discussion on the principle of their introduction and functioning has also reached Polish cities. While today's most popular BRT systems are in the developing countries of Latin America and Asia, their advantages are also gaining popularity in developed countries, including in Western European countries. The increase in the global number of BRT systems and the further development of existing ones, suggests that in many cases BRT systems may prove to be a more efficient form of urban transport than rail solutions, which are the main competitor to BRT systems.

The origin of the BRT concept

The system that started operating in 1974 in Curitiba, in southern Brazil, is considered to be the prototype of the BRT systems and the great success of the idea behind them. The emergence of the BRT system and its further evolution are part of the city's "Curitiba Master Plan" development plan, which has been implemented since 1968. This plan reflected the dynamic growth of the population of Curitiba after the Second World War, with 180,000 in 1950 to 609, 000 in 1970 [16], which caused the increasing communication problems and the "urban sprawl". The main objectives of the "Curitiba Master Plan" have been adopted:

- urban sprawl inhibition,
- congestion reduction on downtown roads,
- preservation of historical and cultural values of the city,
- creating attractive for travellers and economically efficient collective urban transport [9].

The creator of "Curitiba Master Plan", the later 3-fold mayor of Curitiba Jaime Lerner believed that well-functioning city must be developed based on three pillars: mobility, sustainability and identity [10]. These pillars are reflected in the urban-oriented idea of "transit-oriented development," which led to the development of Curitiba. Both the factors identified by Jaime Larner and the idea of "transit-oriented development" take into account the key role that collective urban transport plays in the efficient and friendly inhabitants of cities. Efficient urban transport with controlled land use and hierarchisation of road structures were complementary tools for effective development of Curitiba.

Functioning BRT system in Curitiba consists of 7 transport corridors, radiating from the center of the city off from car traffic. These corridors consist of centrally located double-lane busbars designed to be used exclusively for urban public transport vehicles, roadways, buildings, and single-lane road arteries. These corridors are not only the backbone of the collective urban transport system, but also the north-south and east-west axes along which strictly planned development of urban development. Building hierarchy stimulates demand for collective urban transport by intensifying the urban development in the immediate vicinity of BRT corridors and the construction of lower and lesser buildings along with the increased distance from corridors. These actions are part of the city's development strategy for the development of collective urban transport as a cheaper and more effective alternative to the opposite situation. [6].

Decision of the authorities of Curitiba on the implementation of the collective urban transport using the BRT system using buses rather than rail solutions, allowed to run the system in a relatively short period of time (the first 20 km of bus lanes was completed after 2 years from the plan) [5], at low cost ($ 3 million / km in the case of trams and 50-100 million / km in the case of the subway) [7] and serving a large area of the city (7 corridors with a total length of 84 km). The desire to create a urban transport system with a similar performance to rail solutions, which can be built in a shorter time and therefore lower costs, while ensuring high accessibility and quality of passenger services. The creator of the BRT system in Curitiba Jaime Lerner stated in one of his publications that a generation can not wait to complete the construction of a subway while a functioning terrestrial network can be created within 2 years [10].

According to a study carried out in 1991, 17 years after the implementation of the BRT system in Curitiba, despite one of the highest motorization ratios among the rest of the Brazilian cities, 75% of the city population used collective urban transport, including 28% passenger cars before the development of the BRT system [2]. This has helped reduce the consumption of Curitiba by 27 million liters a year, contributing to one of the lowest air pollution indicators in Brazilian cities [8]. The inhabitants of Curitiba allocated 10% of their wages to transportation needs, which was twice the value of the rest of the country [8].

The positive effects were observed after the introduction of the BRT system and have made them popular all over the world, mainly in the developing countries of Latin America and Asia, and have enabled Curitiba to become the most innovative city in Brazil [1].

Currently, Curitiba is home to 1.9 million people in the city itself and 3.6 million in the metropolitan area [15],[16]. Thanks to a fleet of high-capacity buses and sufficiently efficient point and line infrastructure through BRT bus lanes located in the main transport corridors, daily travel is 560,000. of passengers, with the arrival of 2.2 million passengers [17]. BRT Express passenger services are operated by 29 double-hull buses with a capacity of 250 passengers, 116 double-hinged buses with a capacity of 230 to 250 passengers and 34 articulated buses with 170 passengers [17]. A number of solutions have been developed in the process of evolving the BRT system in Curitiba, increasing the capacity of transport corridors and contributing to improved travel comfort. All vehicles are marked with colors indicating the role they play in the system. Characteristic stops in the shape of a tube are the card of the city, and by separating the streams of passengers embarking and disembarking, they contribute to reducing the stoppage time of vehicles. This time is also reduced by leveling the platform with the vehicle floor and distributing the ticket before entering the vehicle..

RTD compared with other means of transport

In the literature have not made the unification of naming BRT systems, they are also listed under the names:

- Metro-Bus;
- Surface Metro;
- High-Capacity Bus Systems;
- High-Quality Bus Systems;
- Express Bus Systems;

BRT systems in Europe are called BHLS systems, "Bus with High Level of Service" but some researchers believe that BHLS systems can not be included in the definition of BRT systems and thus form a separate category. Others believe that BHLS systems should be considered BRT systems adapted to the conditions and needs of European cities.

The BRT system is defined as a high-quality bus transport system that offers fast, comfortable and cost-effective urban transport by using separate lanes to provide high frequency and speed, as well as a focus on the right marketing tools and high quality customer service [11]. BRT is also referred to as a fast mode of transport that combines the quality of rail transport and the flexibility of bus transport [12].

Both other names used for the system BRT and the above definition present, as system's major competitor, the rail urban transport systems. They also highlighted the main advantages of BRT systems approximating them to rail transport, and therefore a high level of service speed, line capacity and quality of passenger service.

With the emergence of successive BRT systems in the world, the ideas behind this concept have changed. Financial realities, demand, topographic, and the ratio of local authorities to the collective urban transport and spatial some cities introducing BRT systems necessitated the introduction of compromise solutions, not fully enrolling in a strict definition of BRT systems. This has led to the isolation of systems called High-end or Full BRT and Low-end or Lite BRT. The main differences between Full BRT and BRT Lite are shown in the table 1.

Tab. 1. Basic differences between Full BRT and BRT Lite systems (baseline [4])

Features	High-end BRT / Full BRT	Low-end BRT / BRT Lite
Routes	Separated from traffic, dedicated exclusively for BRT vehicles	Only partially separated from traffic
Stops	Air conditioned space, accessible only to travellers, acting as transfer centers.	Most often with carport, seating, lighting and passenger information.
Methods of charging	Fees charged before entering the vehicle, usually using special electronic cards.	Traditional forms of charging.
Used technologies	Electronic real-time passenger information system, vehicle traffic improvement systems, vehicle safety systems and travelers, automatic docking systems for vehicles at bus stops.	Lower level of automation and computerization of services.

The separation of BRT systems into Full BRT and BRT Lite makes it difficult to present BRT systems against other types of urban transport. In addition, there are systems that feature both Full BRT and BRT Lite systems, so they can not easily be assigned to any of the categories. Difficulties in precisely defining the disadvantages and advantages of RTD systems for other types of urban transport are due to the wide range of solutions used in urban bus transport and the differences in rolling stock utilization, route separation, stop construction and service quality and marketing tools used in individual BRT systems. The spectrum of solutions used in urban bus transport is shown in Table 2. BRT systems are divided into three sub-categories: BRT Lite, BRT Heavy and Full BRT. This latest solution is considered to be the most advanced among urban bus transport.

Tab. 2. A spectrum of solutions used in urban bus transport (based on [3])

Type of bus transport	Features
Unregulated bus services	No regular service Services based on taxi model Poor customer service Old tabor and little capacious
Conventional buses	A public or private operator Mostly subsidized Fees charged on the vehicle Stops with the same mark or carport Standard bus fleet
Conventional buses using bus lanes	Restricted lanes Fees charged on the vehicle Simple stoplights Standard bus fleet
BRT-Lite	Prioritizing bus traffic in urban traffic There are no designated bus lanes Shortened travel time Bus shelters with greater comfort Ecological rolling stock Network marketing identification
BRT Heavy	Restricted lanes Fees charged outside the vehicle Stops with greater comfort Ecological rolling stock Network marketing identification
Full BRT	Quality of service comparable to rail Network integration with transport corridors High quality "stop stations" available exclusively for travelers Fees charged outside the vehicle High speed and frequency transport services Nowoczesny, ekologiczny tabor Network marketing identification Higher standard of customer service

Source: Bus Rapid Transit – Planning Guide, 3rd Edition, Institute for Transportation and Development Policy, Nowy York 2007, p. 12.

Table 3 presents the characteristics of BRT systems for tram and urban rail. It follows that BRT systems have the shortest construction time and maximum speed similar to rail transport. Despite the significantly lower capacity of BRT vehicles due to higher frequency of departure, it is possible to achieve line capacity comparable to rail transport.

Tab. 3. Comparison of BRT systems with trams and urban rail (based on [4])

Feature	BRT	Tram	Urban rail
Separation of traffic routes	Total or partial	Total or partial	Total
Surface of the route	Cobblestone, asphalt	Tracks	Tracks
Propulsion	Internal combustion	Electric	Electric
Construction time [years]	1-2	2-3	4-10
Maximum vehicle capacity [carriage]	160-270	500-900 [170-280]	1000-2400 [240-320]
The minimum time that separates the departure of another vehicle from the station [seconds]	12-30	75-150	120-150
The maximum line throughput [number of passengers in one direction \ h]	5000-45000	12000-27000	40000-72000
Max speed [km \ h]	60-70	60-80	70-100

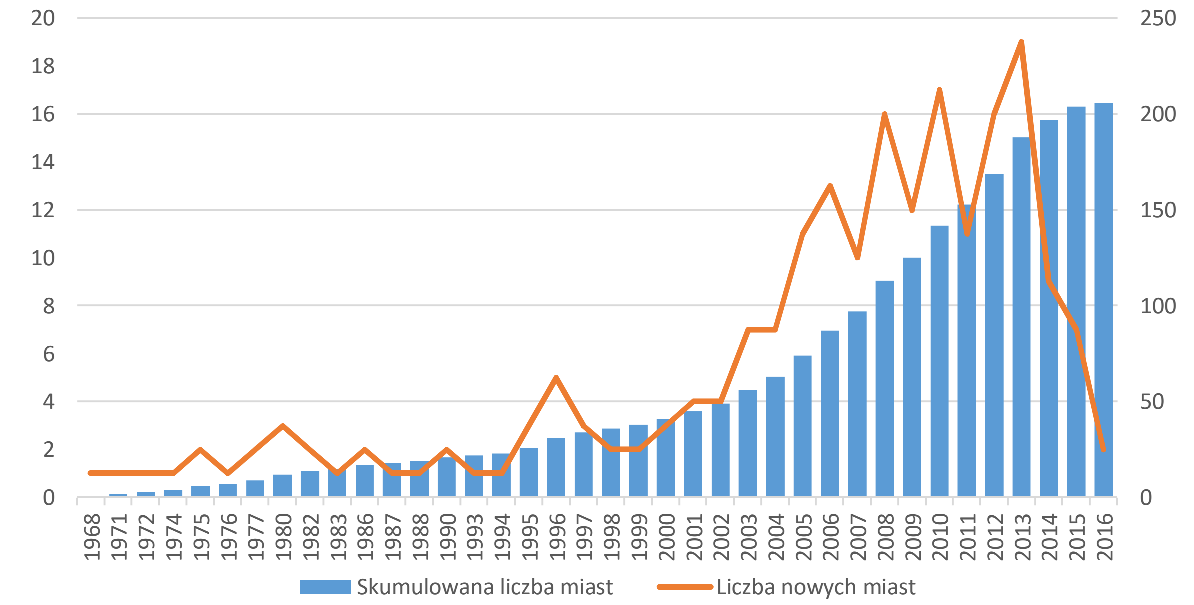
The unquestionable advantage of BRT systems is the cost of construction, which is estimated to be 4 to 20 times lower than the cost of construction of tram lines and 10 to 100 times lower than urban rail [4]. Given the large spectrum of differences between individual BRT systems, it is extremely difficult to estimate their average cost. Among the top-quality systems, labeled as gold, the cost of building infrastructure ranged from $ 26.5 million per km for a system built in 2000 in Bogotá to $ 0.5 million per km for a system built in 2015 in Yichang [13],[14].

Development of BRT in the world

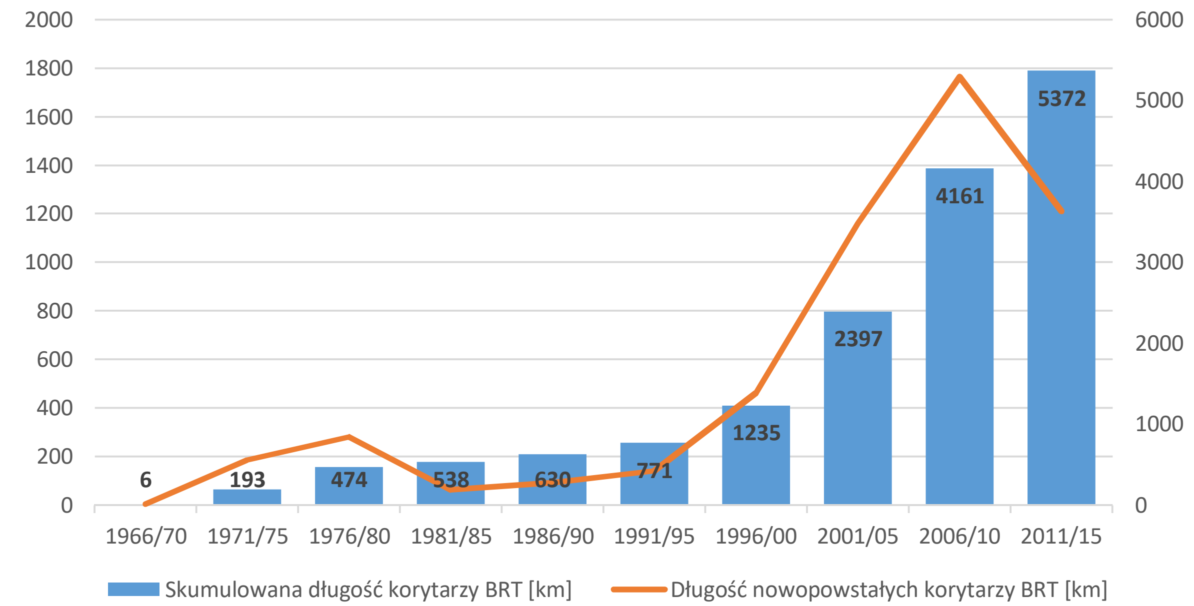
BRT systems are currently used in 206 cities around the world [13]. The greatest popularity gained in South America. In the continent, BRT systems operate in 67 cities in 13 countries. Latin America is also the leader in terms of number and length of BRT systems. These data are presented in Table 4. The evolution of the number of countries using RTD systems is shown in Figure 1. It shows that BRT systems began to gain in popularity in the early twenty-first century, the fastest growth in the number of new BRT systems in the years 2006, 2008, 2010, and 2013. In the years 2006-2010 the fastest keep increasing the length of the corridors global BRT systems, which in 2015 was almost 5400 km. The evolution of the length of BRT corridors worldwide is shown in Figure 2.

Tab.4. BRT systems in different continents in 2015 (ownstudy based on [13])

Features	South America	Asia	Europe	North America	Australia and Oceania	Africa
Number of countries	13	11	14	2	2	2
Number of cities	67	42	59	29	6	3
Number of routes	209	81	72	49	8	4
Length of routes [km]	1 813	1 490	951	919	96	83



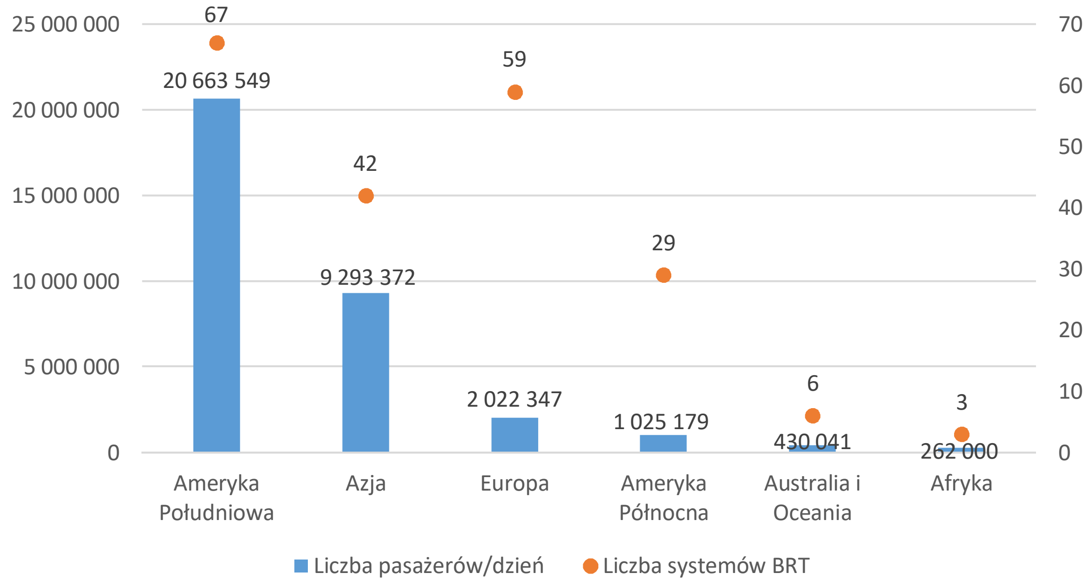
1. Evolution of the number of cities using BRT systems in 1986-2016 [13]



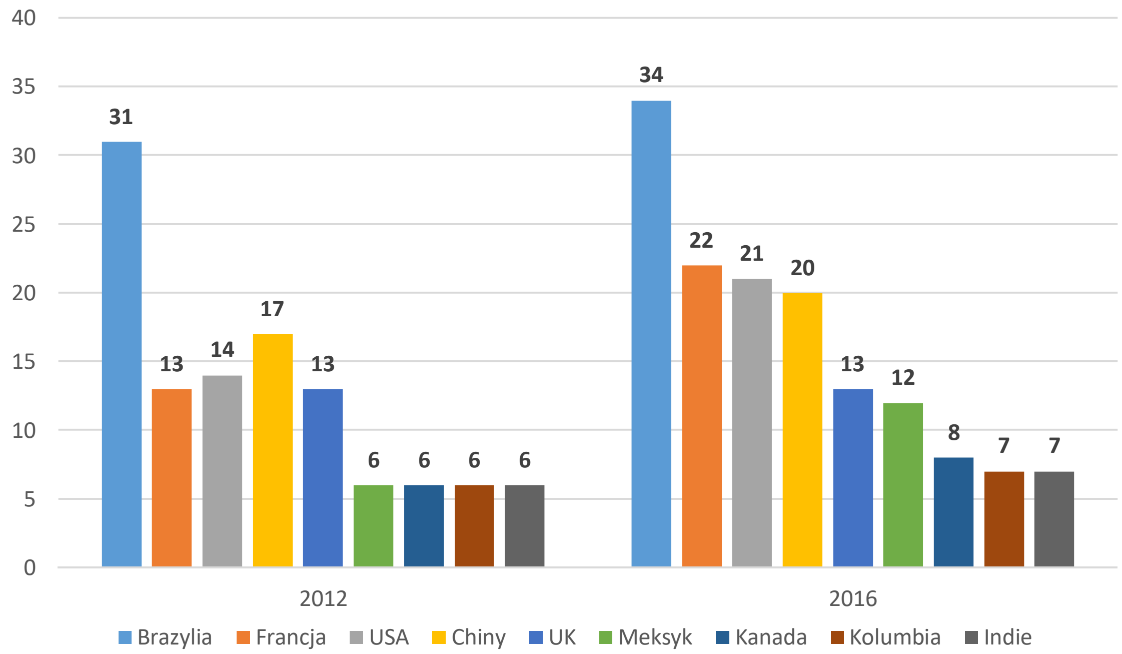
2. Evolution of the global length of BRT corridors in 1966-2015 [13]

BRT systems located in South America numerically represent approx. 32% of all systems in the world, serving approx. 61% of passengers, i.e. more than 20 million passengers per day (Fig. 3). It is in the Colombian city of Bogota that the most efficient BRT system in the world is awarded the Gold Award by the Institute for Transportation and Development Policy. This institute has established uniform measures to evaluate the differentiated RTD systems in the world. Within the framework of the institute, a committee was appointed to give the systems a gold, silver, bronze or "Basic BRT" rating, as well as a non-BRT rating system. Currently only 4 systems have a gold rating, 10 systems have a silver rating, 15 systems have a brown rating and 6 systems have been rated as "Basic BRT" [14].

Apart from South America, BRT systems are very successful in Asia. There are 42 BRT systems in the continent carrying over 9 million passengers a day (Figure 3). Out of the Asian systems 2 were rated as gold, 3 as silver, and 11 as brown. This means that there are 16 out of 29 golden-brown systems in Asia, and the Asian BRT systems are among the most modern and efficient in the world. In China alone, almost 4.5 million passengers use BRT systems (Figure 5). This makes it the second-largest country in Brazil after Brazil with the most developed network of BRT systems in the world in terms of number of served passengers.

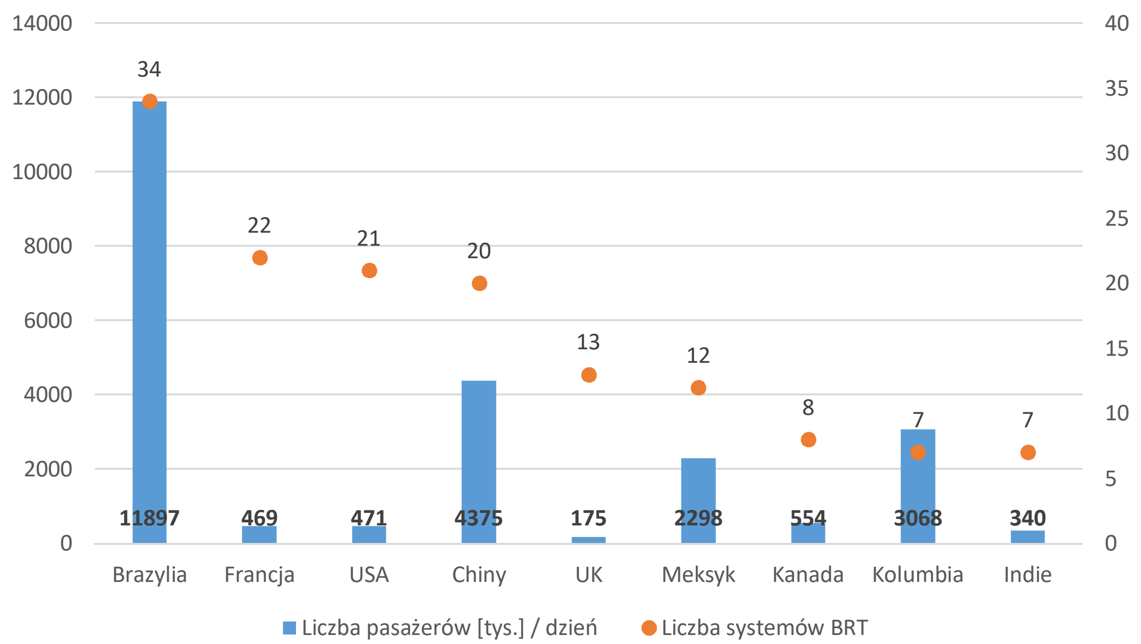


3. Number of passengers on BRT systems in different continents in 2015 (own work based on [13])



4. Evolution of the number of BRT systems in individual countries in the years 2012-2016 (own study based on [13])

Although BRT systems in France, the United States and the United Kingdom are more than a quarter of all BRT systems worldwide, they handle only about 1.1 million passengers per day (about 3% of global demand for BRT systems). This means that in the developed countries the dominant form of collective urban transport used on high demand routes is rail transport, in particular the metro, the city rail and the fast tram. The daily number of passengers in relation to the number of BRT systems in selected countries is shown in Figure 5.



5. Daily number of passengers of BRT systems in selected countries in 2015 (own elaboration based on [13])

Summary
Progressive urbanization entails growing transport problems in cities. For many years the urban rail transport was seen as the only one offering quality and capacity sufficient to handle high urban areas. The BRT system, thanks to its features such as traffic independence, lower construction and maintenance costs, high throughput capacity, and greater flexibility compared to rail transport, allow in many cases to meet transport needs at this level of transport. The benefits of BRT as well as the shorter time needed to complete the investment and the possibility of rebuilding corridors on linear rail infrastructure should further contribute to the further spread of BRT systems around the world.

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