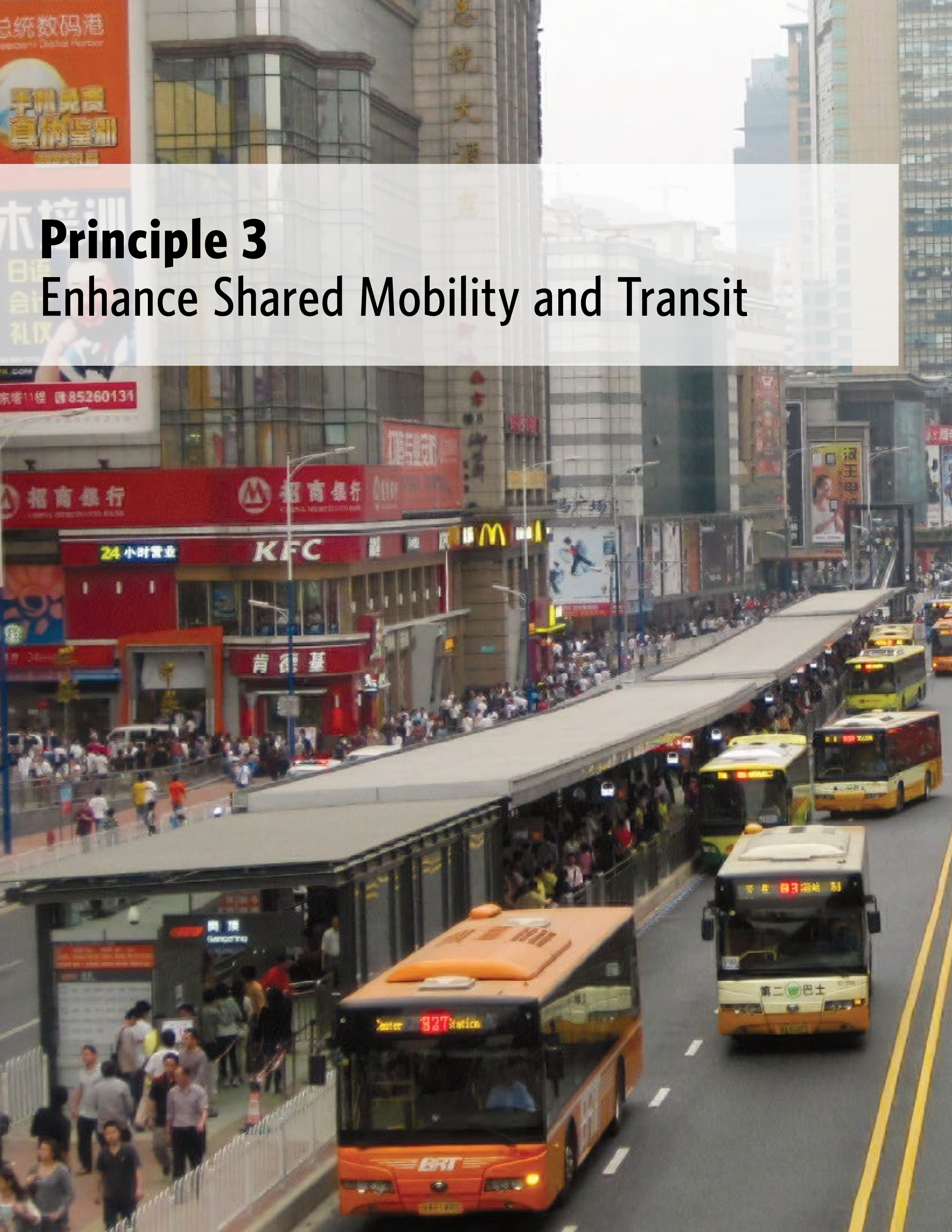
Principle 3
Enhance Shared Mobility and Transit

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Principle 3
Enhance Shared Mobility and Transit

Make networks of transit, new forms of shared mobility, and active transport more desirable, affordable, and ubiquitous

GOALS

3A Ensure frequent and direct transit service with an interconnected hierarchy of transit technologies

ACTION 1: Integrate Metro, bus rapid transit, light rail, streetcar, and bus service with micromobility options

ACTION 2: Build a cross-service, smart transit access system

ACTION 3: Coordinate transit so it is easy to switch modes or lines; limit transfer distance to 100 meters

3B Locate transit stations within a walking distance of homes, jobs and services

ACTION 4: Locate transit lines and expansions to service all new and redevelopment areas

ACTION 5: Plan a grid of dedicated transit lanes that can be used for BRT, light rail, streetcar, or autonomous shared vehicles

ACTION 6: Emphasize the bike connection to major transit stations

METRICS

3.1 Transit Plans

Create a transit plan which ensures that megacities have a public transit mode share of 35 percent, big cities have 30 percent, and small- and medium-sized cities have a public transit mode share of 25 percent or more.

3.2 Distance to Transit

All major housing and job centers should be within 500 meters of a local transit station and 1,000 meters of transit service with exclusive right-of-way

RATIONALE AND CHALLENGE

Transit and new forms of shared mobility must be at the heart of transportation in the next generation of cities. Private occupant vehicles—even electric and autonomous—cannot make our communities livable nor sustainable. Forms of shared mobility range from traditional grade separated Metro systems or at-grade light rail and new forms of bus rapid transit (BRT) using autonomous technology to basic bus service and informal jitney service. Regardless of the mode, the key to high ridership is frequent service and exclusive rights-of-way to make transit trips time competitive with autos. Making such a range of transit accessible and an option that works across all levels of income is one of the best ways to reduce car dependence.

Enrique Peñalosa, former mayor of Bogotá, Colombia once said that "An advanced city is not a place where the poor use cars, but rather one where even the rich use public transport."[1] Many of the greatest cities are known for their public transit systems; Tokyo, London, Hong Kong, and Singapore are excellent examples. In these places, most commutes are by transit, not cars, even though large fractions of the population are affluent and can afford to drive. In these places where robust public transit systems are possible, transit networks must be well integrated with walking, biking, and other forms of micromobility to solve the "last-mile" question of how people will get to their final destination.

China represents a good global example of a large-scale commitment to transit in many forms and its many challenges. It has invested a substantial amount into transportation networks throughout the past few decades, both at the national and local scales. High-speed rail systems now total over 35,000 kilometers in length. Its urban Metro systems are funded and designed based on high-target mode splits that demonstrate over 60 percent of trips made via transit or active transportation in its most populous cities.[2] More bike-share systems are available in China than the rest of the world's systems combined. China also has one of the highest numbers of bus rapid transit systems globally and is now on the cutting-edge of developing fast-charging electric and autonomous buses. Yet Chinese cities are still dealing with the typical problems of congestion, rising rates of vehicle ownership, pollution, sprawl, the last-mile access, and insufficient financing. Congestion is increasingly becoming a bottleneck for economic growth even with large transit investments and leading transportation technology.

For many parts of the developing world, the China model is unaffordable. Often challenged by minimal funding for transit and infrastructure, developing cities can consider low-cost alternatives that are easier to implement and adapt to various patterns of development. Bus rapid transit and new forms of shared mobility, when designed well, can function just as well as a Metro and cost much less. When designed poorly though, these systems can perform the same as or worse than a bus system. Figure P3-1 shows the quantitative breakdown of a BRT compared to light rail transit (LRT) and Metro. Construction time, capital costs, and operating costs are all much lower for BRT, while through-line capacity can be comparable to metro and even better than light rail. Brazil's Curitiba BRT stands as a prime example of the success bus rapid transit systems can reach when well designed. With its high frequency, dedicated lanes and low-fare and implementation costs, the Curitiba BRT is one of the most heavily used transit systems in the world.

Autonomous vehicles (AVs) represent many options for mobility in the future, with some good and some bad outcomes. If AVs are used privately, studies show additional vehicle miles traveled (VMT) could explode by 30 percent due to longer commutes, induced trips, and inefficient use.[3] If deployed as a taxi service, the increase in VMTs could be even greater because of single-occupant trips, deadheads, and empty vehicle miles. These applications can exacerbate sprawl for high-income groups no longer inhibited by long commutes and increase congestion due to increased VMT per capita. On the other hand, if deployed for shared trips, particularly on dedicated rights-of-way, AVs may emerge as an important new, accessible, and affordable form of transit. Perhaps through thoughtful policy that promotes high capacity and shared occupancy in AVs, cities can effectively use this mode to cover last-mile trips, improve systemwide mobility, and lower rates of vehicle ownership. The key to success in all forms of transit from a cost, efficiency, and environmental standpoint is its level of shared occupancy.

A hopeful new technology deploying autonomous vans or minibuses on dedicated lanes may provide affordable and ubiquitous service in ways not available today. Some cities have considered replacing a portion of their conventional bus lines with demand-responsive shared autonomous vehicles for more flexible routes and greater frequency. Shared AVs like this could cover the "last-mile" gap between public transit stops and final destinations while potentially lowering operation cost per vehicle when compared to conventional taxis as AV technology progresses. Despite these potential benefits, shared AVs pose numerous challenges like travel time and the limitations of current AV technology that may delay their integration into transportation networks.

Facilitating connections to micromobility modes within transportation networks can encourage commuters to use more sustainable transportation options. Micromobility can offer scalable solutions to cities across the globe—providing low-cost, quick to implement infrastructure alternatives that can reduce congestion and urban sprawl. Across the globe, the use of e-scooters and numerous forms of bikes is on the rise—whether they are privately used, part of a share system, or employed as a taxiing service. As the use of these modes continues to grow in popularity, cities must consider how to formalize, integrate, and maximize the potential of micromobility in existing infrastructure.

In many developing cities, motorcycles are a common way of commuting that offers lower cost transportation along congested streets. In a 2010 World Health Organization report dedicated to powered two- and three-wheelers (PTWs) safety, the WHO found that PTWs cause 286,000 deaths each year and, as a result, suggested dedicating separate infrastructure for PTWs.[4] As the use of powered two- and three-wheelers is on the rise, particularly in developing countries, a growing need exists for safer PTW infrastructure and sustainability parameters that can minimize pollution impacting human health and welfare. In cities where motorcycles are dominant, like Ho Chi Minh City in Vietnam and Quezon City in Manilla, electric bikes with dedicated lanes and streets can offer mobility that has similar capacities but is cheaper and just as clean as traditional transit. These investments can be anything from dedicated, sheltered lanes running parallel to traffic to grade-separated, multi-lane "superhighways."

An important transportation design consideration is the growing role of low-income sprawl in developing economies. As developing cities become more populated and more expensive, many low-income residents cannot afford housing in the dense, central urban areas coincident with better access to transit. Throughout the world the poor suffer most with long, slow commutes. In Mexico City, many living at the urban edge commute up to three hours each way to work, relegated to low quality and inefficient informal bus systems. This consequence of sprawl will continue to be an obstacle to mobility among lower income groups and a challenge to be addressed in cities' relationships between public transportation and land use.

CHARACTERISTICS OF BRT, LRT, AND METRO

	BUS RAPID TRANSIT	LIGHT RAIL	METRO RAIL
Rights-Of-Way	Mixed; shared (at-grade); dedicated and exclusive lanes	Exclusive (elevated or barriers) or shared (at-grade)	Exclusive; grade-separated
Running Ways	Pavement; roadways	Steel track	Steel track
Vehicle Propulsion	Internal Combustion Engine	Electric (overhead wires) or third rail where possible	Electric (high voltage third rail)
Vehicle Control	Operator/Visual	Automated/Sign Control	Automated/Sign Control
Construction Time	1–2 years	2–3 years	4–10 years
Maximum Capacity (passengers/vehicle unit)	160–270	170–280	240–320
Maximum Capacity (passengers/coupled unit)	160–270	500–900	1000–2400
Maximum Speed (km/h)	12–30	75–150	120–150
Line Capacity (passengers/direction/hour)	5,000–45,000	12,000–27,000	40,000–72,000
Maximum Speed (km/h)	60–70	60–80	70–100
Average Capital Costs (million US$)	8.4	21.5	104.5
Average Operating Costs (US$ per vehicle revenue km)	2.94	7.58	5.30

Figure P3-1: Comparison of public transit systems. (Data sources: Levinson (2003); Vuchic (2005); Hensher and Golob (2008); Zhang (2009); Deng and Nelson (2011))

BENEFITS

ECONOMIC

Decreases cost of congestion: High-quality public transportation shifts commuters away from energy-intensive private vehicles, which reduces traffic congestion.[5]

Increases property values: Being located near transit increases real estate values. Proximity to public transit stops has led to price premiums of 11 percent in Hong Kong, 14 percent in Bogota, and an annual increase of 2.3 percent in Beijing. [6]

Decreases transportation costs: People living in cities with the best public transportation systems spend less of their household budgets on transportation. This contributes to the overall affordability of compact cities.

ENVIRONMENTAL

Decreases carbon emissions: Effective public transit systems decrease emissions. For example, transportation-related emissions are 30 percent lower in China's Hankou district with its compact urban fabric and good transit in comparison to the Hanyang district that is characterized by low road density and a high proportion of car commuters.[7]

Improves air quality: Public transit produces less CO_2, NOx, and PM2.5 than car travel.[8]

SOCIAL

Increases access for disadvantaged groups: High-quality public transit can improve transit times and accessibility of transportation for people of all ages and income groups.[9]

Lowers crash risk: Transit travel has about one-tenth the rate of crash deaths or injuries as car travel.[10]

Builds social ties: Compared to car travel, public transit is a shared experience, thus helping to build social ties and community.

CASE STUDY

Curitiba Rede Integrada de Transporte

Rede Integrada de Transporte (RIT) is a bus rapid transit system in Curitiba, Brazil, totaling over 80 kilometers in length. The RIT is a prime example of a well-planned, well-integrated BRT system that directed the development of a growing city around accessible transit. In 1974, rather than invest in the high-cost light rail system under consideration, Curitiba used federal funding available for bus systems performance to invest in busway corridors to guide the city's development along transportation lines in accordance with its master plan.[11] This approach heavily shaped the urban landscape of Curitiba, creating linear, high-density, transit-oriented development along major commuter corridors.

What started as a conventional system of bus lines mixed with traffic has evolved, with constant improvements, into one of the most robust BRT systems in the world. The Institute for Research and Urban Planning of Curitiba developed a trunk and feeder bus system to provide coverage and frequency throughout Curitiba. The system is now comprised of a network of feeder bus routes that run in mixed traffic on local roads and higher frequency trunk routes running along dedicated bus lane corridors leading into the city center. Passengers board and alight at RIT tube stations that provide shelter, enable payment prior to riding, and allow for same level boarding for efficient and accessible loading and unloading.

As part of the C40 Cities Climate Leadership Group that aims to promote sustainability, Curitiba uses alternative fuels in a portion of their fleet. Some of Curitiba's buses run with soybean-based biodiesel while hybrid biodiesel-electric buses provide service along a few feeder routes.[12] These alternatives not only provide options for improved air quality but also support Brazil's job market as a major producer of soybeans and ethanol.

The RIT's flat fare covers transportation cost disparity between passengers with short and long commutes by allowing unlimited transfers between trunk and feeder routes at tube stations and terminals. In cities where the working class can only afford to live in outer ring neighborhoods and must endure longer commutes into centers of employment, flat fare structures like the RITs provide equitable access to public transit across income groups. With its low-cost, high-frequency, and wide-spread coverage, the RIT is one of the most heavily used transit systems in the world. Even after 40 years of operation, the RIT continues to be cited as the inspiration for newer BRT systems across the world.

Figure P3-2: RIT's Marechal Floriano BRT station (Source: Mariordo (Mario Roberto Duran Ortiz), CC BY-SA 3.0, https://commons.wikimedia.org/wiki/File:Linha_Verde_Curitiba_BRT_02_2013_Est_Marechal_Floriano_5970.JPG

GOAL 3A:
Ensure frequent and direct transit service with an interconnected hierarchy of transit technologies

Establishing a grid of high-capacity, high-speed transit corridors at regular intervals with dedicated transit lanes where possible will ensure that transit service is frequent and direct. An integrated multi-modal system where the transition from one mode of transit to another is seamless, efficient, and fast will encourage ridership by reducing dependence on the automobile and minimize the number of transfers needed for most passengers. There are many forms and technologies for transit (i.e., local bus, streetcars, BRT, LRT and Metro) and differing types of service (i.e., express, local, and shuttle to name a few). Regardless of technology and vehicle type, two significant categories of transit include those with dedicated, transit-only right-of-ways and those that travel in mixed-flow lanes. Those with dedicated right-of-ways (metro, BRT, and most LRT) are key to long-distance effective transit and form the backbone of any major city's system. Local systems in mixed flow lanes are slow but provide access to most locations and if coordinated well, act as feeders to the primary system and local destinations. In all cases, the key to good transit is the seamless integration of the differing systems and services. One-ticket systems aid people to shift and combine rides while new wireless information systems that show arrival/departure times as well as mapping routes are new systems of integration that can make transit more accessible.

Figure P3-3: With its frequent service, high reliability and well-designed stations, the BRT system in Quito, Ecuador serves as a model for bus rapid systems around the world. (Source: Helder Ribeiro, CC BY-SA 2.0)

Figure P3-4: A bus station along the Guangzhou Bus Rapid Transit corridor provides live departure and arrival information making transfers convenient and seamless. (Source: Tim Wu, CC BY-SA 4.0)

ACTION 1:
Integrate Metro, BRT, light rail, streetcar, and bus service

Hong Kong SAR China, New York City, Singapore, and Tokyo have some of the densest public transit networks in the world serving as good examples of integrated, multimodal systems. While Metro can be an integral part of a transit network, a growing number of cities are turning to BRT for its low cost, quick implementation, and flexible routes. Each city will need to determine the appropriate mix of transit solutions for its conditions, but cities can guarantee the overall success of their transit by providing frequent, fast, and direct service in easily accessible locations. By integrating different types of transit—Metro, BRT, light rail and bus service—cities can ensure that the transit system is convenient, quick, and seamless.

Figure P3-5: The Tianjin Railway Station in China is a multi-modal station and serves as an important transfer hub between the high speed rail lines and the metro, providing convenient and efficient transfers. (Source: Matthew Summerton, CC BY-SA3.0)

ACTION 2:
Build a cross-service, smart transit access system

Allow users to have one card they can charge through mobile, web, or kiosks that can be used across metro, BRT, buses, and bike-sharing programs. Too many cities have multiple systems each with its own ticket and fare systems. Integrating the systems with easy ticket passes reduces one barrier to transit use. The Republic of Korea's T-money is a good example of a contactless integrated fare payment system in which riders can use smart cards and devices to pay for various transportation modes in and around cities. Some attractions and stores also accept payment through T-money, further incentivizing the use of the technology.

Figure P3-6: A multi-day mobile ticket is validated on-board by scanning a QR code in Austin, Texas, USA (Source: Adobe Stock)

ACTION 3:
Coordinate transit so it is easy to switch modes or lines; limit transfer distance to 100 meters

Local bus lines should have easy links to the rail and BRT systems of a city. Transfers must be designed to reduce friction and time for those moving between modes and lines. A maximum of 100-meter walk distance should be maintained between all stations of a multimodal station. Walking and biking access must be integrated with all public transit options with safe, convenient routes and bike storage. Smart technologies can aid in real-time transit data and optimizing dispatch.

Figure P3-7: The Octopus Card allows people to travel between the various transit systems throughout Hong Kong with ease. (Source: User Experience)

GOAL 3B:
Locate transit stations within walking distance of homes, jobs, and services

In order to ensure high transit utilization, the system must connect most origins and destinations with appropriate capacities and service levels. This means that all major destinations and most residential areas will need frequent transit service. In most cities, this means that dedicated right-of-way service of Metro or BRT is needed within 1,000 meters of primary developed areas and local feeder bus service within 500 meters of all housing. In new developing areas, the location of differing transit stations can be complemented by transit-oriented urban development that increases density and services near primary stations. The feeder bus systems should coordinate with trunk lines and have seamless transfer routes.

ACTION 4:
Locate transit lines and expansions to service all new and redevelopment areas

No new development areas should be planned without adequate transit service. In fact, plans for a new area should structure its distribution of use and density around the projected transit service. Mixed-use and residential districts should have primary transit service to city center and major employment areas, as well as local bus service. In order to efficiently provide high-capacity transit, it is best to mix light industrial and R&D parks near commercial and residential areas where one line can service multiple uses.

Figure P3-8: The Al Rabwa mixed-use development located in central Riyadh, Saudi Arabia offers a sustainable approach to providing a variety of residential and commercial uses with transit accessible destinations and walkable neighborhoods. (Source: HDR | Calthorpe)

ACTION 5:
Plan a grid of dedicated transit lanes which can be used for BRT, light rail, streetcar or autonomous shared vehicles

As new development areas are planned, a network of dedicated transit lanes can be reserved for BRT and LRT systems as well as future autonomous transit. As new street sections and rights-of-way are designed, it is relatively simple to add space for transit even when demand is low. These lanes are flexible as they can be temporarily landscaped as part of a median or paved and used for local buses. As ridership grows, more advanced stations and boarding facilities can be added. Express, skip-stop lanes should be considered for ultimate system capacity and space should be reserved in new rights-of-way.

Figure P3-9: Street concept with dedicated bus lanes. Dedicated transit lanes improve transit efficiency, speed, and convenience. (Source: "Urban Street Design Guide," NACTO)

BEFORE BUS RAPID TRANSIT

Figure P3-10: Tianfu Lu intersection before bus rapid transit was introduced in Guangzhou, China (Source: ITDP)

AFTER BUS RAPID TRANSIT

Figure P3-11: Tianfu Lu intersection after bus rapid transit was introduced (Source: ITDP)

ACTION 6:
Emphasize the bike connection to major transit stations

Direct access to major stations by bike or walk is always simpler than feeder buses. Given a robust network of bike lanes, commute trips can easily be handled by a combination of bike and transit if the connections are complete and safe. Equally important for commuters is safe, cheap, and close bike storage facilities. Major new Metro stations in residential districts should provide adequate service. In major commercial destinations, bike share systems can facilitate access to jobs beyond a walking radius.

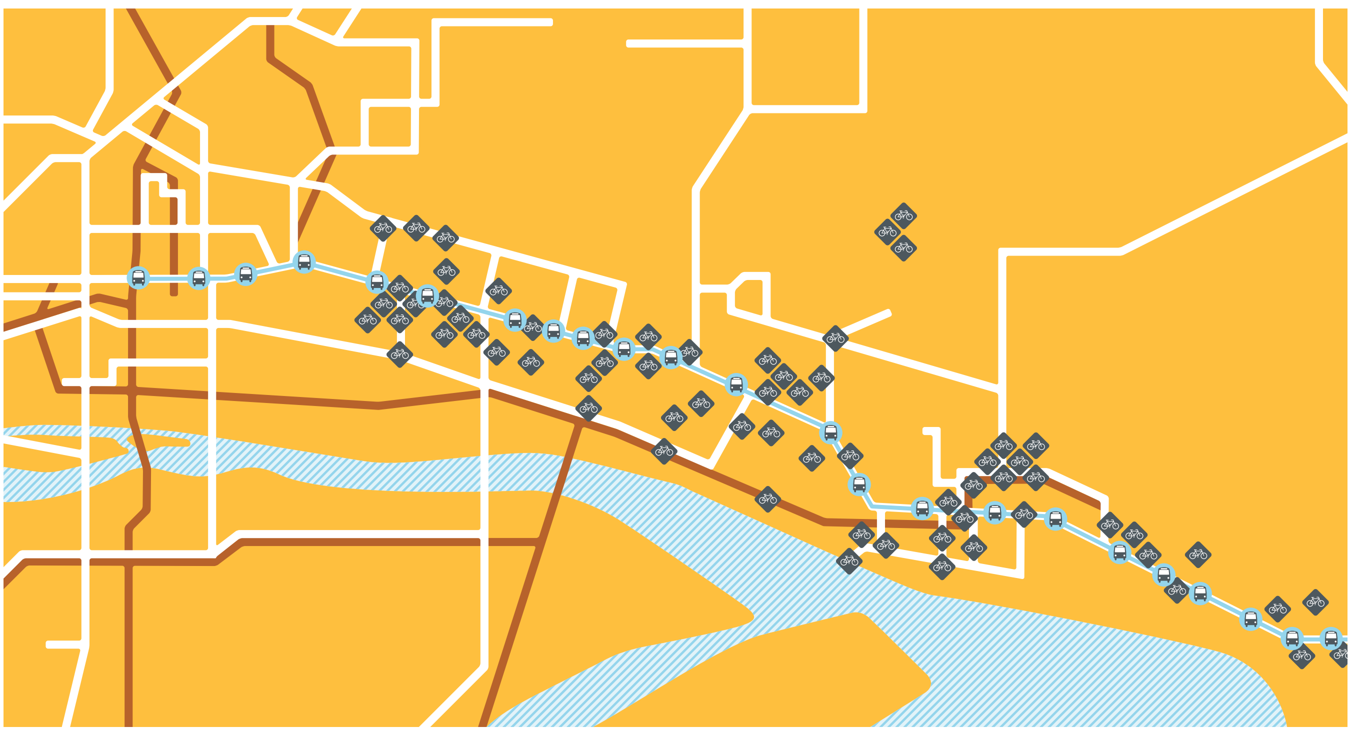

Figure P3-12: The Guangzhou BRT system integrates with bike lanes, bike share and Metro stations. In 2010, it launched its bike sharing program with 5,000 bikes and 113 stations primarily along its BRT corridor. Provisions were made to ensure that there were sufficient bike parking positions (5,500) at BRT stations. A polluted former canal was converted to the Donghaochang greenway, which created a four-kilometer bike and pedestrian path providing connections to the BRT corridor. The BRT system moves 27,000 passengers per hour per direction during peak commute hours and integrates with bike lanes, bike sharing stations, Metro lines, and other feeder bus systems. (Source: ITDP)

LEGEND:

- BRT Station
- Bike Sharing Station
- BRT Corridor
- Bus Line
- Metro Line

METRIC 3.1:
Transit Plans

Create a transit plan that ensures that megacities have a public transit mode share of 35 percent, big cities have 30 percent, and small- and medium-sized cities have a public transit mode share of 25 percent or more

Accomplishing these goals is a complex task involving investments in transit, system integration, walk/bike environments, and land-use planning. The essence of this goal is developing a transit plan that makes transit accessible to all people in a region, provides affordable service, moves at reasonable speeds, and connects to key regional destinations and employment centers. The challenge is always the cost of capital improvements and operations and maintenance.

Those cities that prioritize transit infrastructure and accessibility show the highest rates of ridership. As a megacity with a robust and integrated transit system, Tokyo reports a 47 percent transit mode share.[13] London's extensive and convenient transit system translates to a near 30 percent transit mode share while Stockholm boasts an impressive 32 percent mode split for transit.[14 15]

For developing cities, at-grade dedicated right-of-ways are key to enhancing the functionality of informal transit modes. Each city will evolve with a differing mix of transit types and density of stations; however, in all cases, the principles of transit-oriented development and walkable/bikeable streets will enhance the efficacy of the transit investments and convenience for the riders. In addition, a healthy jobs and housing balance, higher density development, and mixed-use in all areas of the city will enhance transit in any form. The use of local feeder systems integrated with high-capacity regional transit on dedicated lines will be essential to all cities.

METRIC 3.2:
Distance to Transit

All major housing and job centers should be within 500 meters of a local transit station and 1,000 meters of transit service with exclusive right-of-way

Station proximity is key to transit convenience and ridership. It is typical and easy to provide local bus service within 500 meters of all urban residential developments. Enhancing this with transit systems with dedicated right-of-ways such as BRT is a goal that will increase ridership, reduce road congestion, and reduce travel times. In addition, such systems can reduce energy consumption, operation costs, and air pollution. They are relatively easy to implement in new growth areas where right-of-ways and land-use can reinforce the lines. Retrofitting transit in existing areas typically involves reducing mixed flow traffic lanes in favor of transit capacity. In central city areas, grade-separated lines should be considered to reduce delay at intersections while preserving surface rights-of-way for enhanced walk/bike facilities.

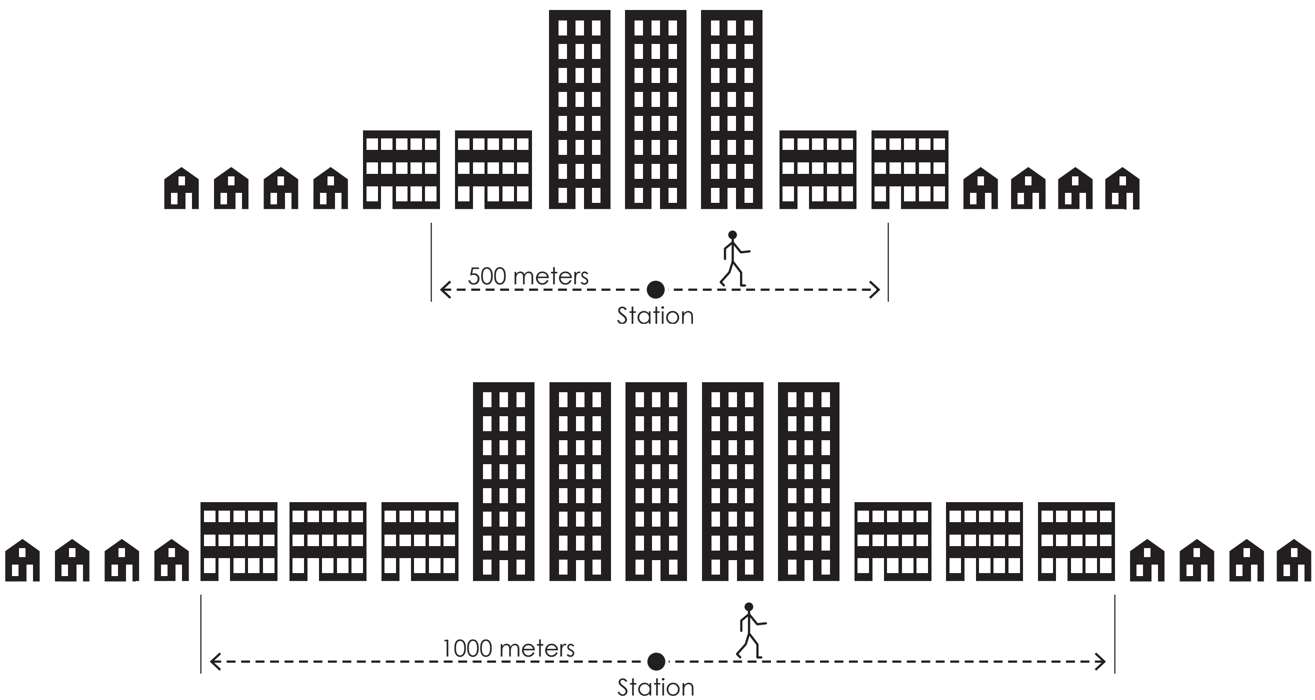

Figure P3-13: Housing and job centers should be within 500 meters of a local transit station and 1,000 meters of transit service with exclusive right-of-way. Development must be oriented towards transit to help reduce dependence on automobiles and improve transit accessibility. (Source: HDR | Calthorpe)

CASE STUDY

Ahmedabad, India

Population: 7,571,000 [16]
2030 Forecast: 10,527,000 [17]
Size: 464 km^2 [18]

JANMARG BUS RAPID TRANSIT: LEAPFROG INTO A 21ST-CENTURY MASS TRANSIT NETWORK

Janmarg is the first BRT in India and a model for mobility solutions in the developing world. Janmarg was inaugurated in 2009 with 45 kilometers of dedicated BRT lanes; phase two expanded it to 89 kilometers; and phase three is set to extend service to the outskirts of the city with a station every 500 meters for ease of access. In total, the system will span 143 kilometers of trunk bus service, covering 73 percent of the city's population within walking distance from a station. Local buses and last-mile providers such as rickshaws or taxis act as feeders. For enhanced safety, the system offers women-only buses, a measure currently studied by other BRT system operators, such as in Bogotá.[19]

The choice to construct a BRT system fit India's typical scenario of inserting infrastructure within a dense, randomly developed urban form. BRT corridors served an existing demand for localized trips in a patch-work urban fabric that doesn't have a singular central business district, and provided a flexible, expandable and comparably affordable transit solution. Decision-makers realized that the choice of Metro or BRT means a single, short Metro line, or a complete system that would be able to significantly change mode-share habits. The project was developed by the Gujarat Infrastructure Development Board (GIDB) and funded in part by a national urban renewal program, JuNURM.[20] Elected officials sought successful innovation and helped facilitate a quick implementation. Janmarg won Government of India's 2009 Best Mass Rapid Transit System award and the Institute for Transportation and Development Policy Sustainable Transport Award for 2010 and gained recognition as a model for other cities in India including Bangalore, Amritsar, and others that are following Ahmedabad's lead.[21]

From the latest available data, usage patterns show daily ridership is 130,000, with most users replacing older transit systems.[22] Thirteen percent shifted from a motorized vehicle.[23]

Figure P3-14: Kankaria Lake BRT Station. Public space improvements near stations help increase transportation mode shift. (Source: Amcanada, CC BY 3.0)

However, between 2009 and 2017, bus ridership in the city fell 25 percent.[24] The shortcoming is explained by low utilization of transit-oriented development potential, with little public benefit from land value hikes near stations.[25] At the same time, a significant rise in private vehicles ownership was seen. Another problematic aspect is last-mile access to stations for pedestrians and bikes.

As part of the Action Plan for Control of Air Pollution in Ahmedabad, Janmarg now operates 140 e-buses starting in 2021.[26] The buses are propelled by fast-charging batteries and can run up to 250 kilometers between each charge. Fast-charging stations dispersed along the BRT routes allow for minimal interruption throughout the day. These e-buses are expected to save 1,000 tons of carbon dioxide as well as 350,000 liters of diesel over their anticipated 10 years of operation.[27]

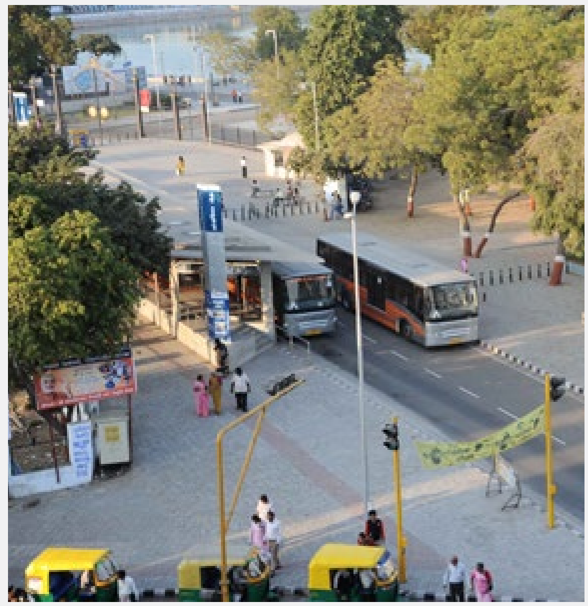

Figure P3-15: High mode share for rickshaws, bikes and walking enable BRT to suppress demand for cars and avoid a car culture future. (Source: ITDP India)

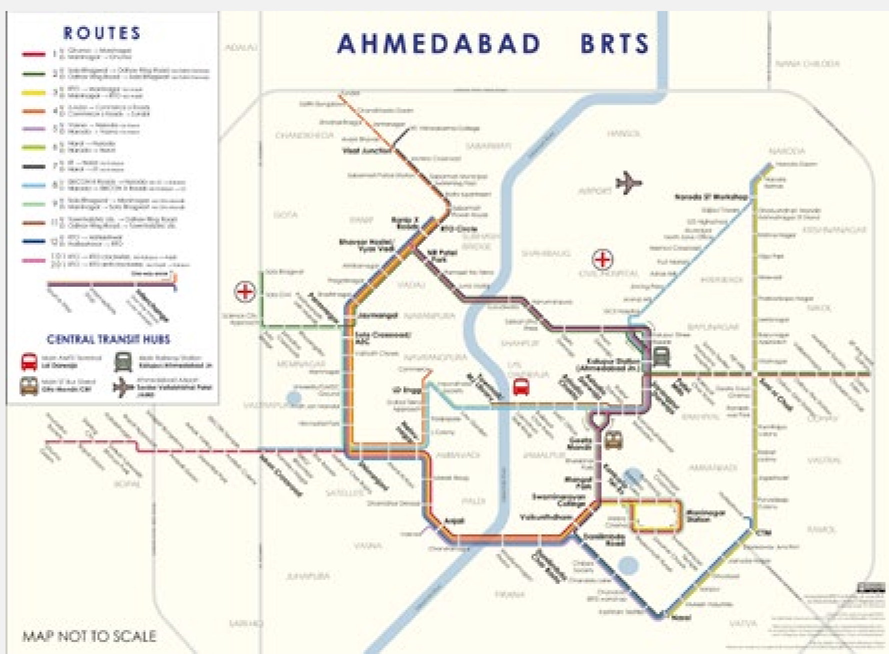

Figure P3-16: Diagram of the Janmarg BRT Network. (Source: Shaval Shukia, CC SA-BY 4.0)

CASE STUDY

Grand Boulevards: Bay Area, California, USA

Population: 7,760,000 [28]
2030 Forecast: 8,689,440[29]
Size: 18,040km^2 [30]

A VISION OF ON-DEMAND, 24/7 AUTONOMOUS RAPID TRANSIT ALONG A NEW GRAND BOULEVARD

A recent study by HDR and UrbanFootprint, an urban intelligence software platform, found that the underutilized commercial land lining the San Francisco Inner Bay Area's 700 miles of arterial roads totaled a staggering 15,400 acres. This discovery inspired a new vision for the Inner Bay's strip malls that transforms underutilized commercial corridors into vibrant, mixed-use "Grand Boulevards." If redeveloped, this land could potentially provide nearly 1.37 million new houses that are accessibly linked to transit and close to jobs and existing services—most of it right in the Silicon Valley where housing is a great challenge. Along these boulevards, the next generation of transit could emerge, providing a mobility solution for cities plagued with the adverse effects of high-income sprawl like long commutes, high household transportation costs, and access to transit.

Autonomous rapid transit (ART) may be the solution for quick-to-implement, on-demand transit. ART is the application of AV technology in higher capacity, shared vehicles that run on dedicated transit lanes similar to those used in BRT systems. AV systems run more safely and efficiently in dedicated lanes where they can travel closer together in 'platoons' that reduce the amount of road space

Figure P3-17: The El Camino arterial in Silicon Valley shown enhanced with wide sidewalks, bikelanes, tree cannopy, and BRT system (Source: HDR) occupied and communicate with each other to coordinate movements through intersections, thus improving traffic flow.

In dedicated lanes along these conceived Grand Boulevards, adding autonomous, shared vans that use smart algorithms to cluster origins and destinations could provide on-call, express trips 24/7. Quick, inexpensive, and ubiquitous service might just be the ticket to get people out of their cars, relieving the Bay Area's roads of their infamous congestion.

Faster and less expensive to build and operate than any current transit system, driverless transit tech is currently being tested in places like Singapore and Hunan. Like BRTs, ARTs are flexible in their routes as they run on road surfaces and not fixed rails. Consequently, their routes can be more easily adjusted at a lower cost than rail. Fehr & Peers, a leading transportation firm, estimates the construction cost at 15 percent of most light rail systems, with half the operating cost, all while moving passengers 30 percent faster. As AV technology improves, it could also minimize the operational costs of BRT by eliminating the need for drivers. ART could also reduce VMTs by adjusting capacity according to time and place to meet demand and lowering travel time for many passengers by providing direct service to destinations. This reduction in VMTs would reduce vehicle emissions and improve air quality within communities along the Inner Bay Area's major corridors.

This approach may be a feasible next step for regions like the Bay Area that are challenged with high-income sprawl and an auto-dependent culture. ARTs achieve the efficiency of AV flow without eliminating private vehicles from city streets. As it progresses, ART could initiate a feasible, smooth transition from private vehicle ownership to a more sustainable, shared-transit environment in which privately owned vehicles are a rarity rather than necessity.

Figure P3-18: The El Camino "grand boulevard" with ART vans in protected lanes (Source: HDR)

CASE STUDY

Singapore

Population: 5,638,700[31]
2030 Forecast: 6,900,000
Size: 728.6km^2 [32]

COMMERCIALIZING AUTONOMOUS MOBILITY: SINGAPORE'S DRIVERLESS BUS PILOT

In January of 2021, Singapore's Alliance for Action (AfA) on Robotics launched a three-month autonomous electric bus trial that ran throughout two locations: the Singapore Science Park 2 and Jurong Island. While Singapore has been home to numerous autonomous bus trials since 2015, this iteration of the driverless bus was the first AV bus service in Singapore to collect fares and generate revenue, bringing Singapore one step closer to its goal of public and commercial deployment of AV technology. The trial was developed by the AfA to gather data on the performance of AV buses in a public setting and provide a near-future solution to their manpower shortage in the public bus sector, allowing the city-state to reduce their reliance on foreign labor.

The two routes that follow a loop path were intentionally designed to test different physical conditions, vehicle types, operation structures, and commuter mixes. The buses operated on an on-demand basis that was facilitated by a booking app in which passengers could pay their fares with credit or debit cards prior to boarding. Science Park 2 was operated by seven-meter-long, 10-seat minibuses while Jurong Island was covered by a 26-seater city bus.[33] On both routes, the AfA aimed to serve off-peak trips when public transport typically ran at a lower frequency. The routes covered last- and first-mile connections to Mass Rapid Transit (MRT) stations as well as short errand trips like grabbing lunch at a nearby food court.

By the end of the driverless buses' three-month trial, no incidents were reported and 6,000 passengers were served.[34] Still, the capabilities of the driverless buses are limited by the current state of AV technology as well as the Land Transport Authority's regulations on autonomous vehicles that dictate low speeds and operation among less trafficked roads. While the buses can navigate and operate on their own, they rely on the presence of a dedicated "safety operator" to take control if necessary and manually steer at the few stretches of routes where Singapore restricts AV usage. As AV buses currently exist within Singapore, they are best suited for local trips and can accommodate on-demand service.

ST Engineering developed the technology behind the driverless buses while working with multimodal transport operators, SMRT and SBS Transit, to operate the buses. Stakeholders from the National Transport Workers' Union were engaged by the AfA throughout the development and operation of the pilot to provide insight and plan for the training of safety operators as well as commuter experience and bus system managers that will be needed in the future. [35]

Figure P3-19: An on-demand autonomous bus developed by ST Engineering departs from bus stop after picking up passengers at the start of a trial run from Singapore Science Park 2 to Haw Par Villa MRT station in Singapore on January 26, 2021. (Photo by ROSLAN RAHMAN/AFP via Getty Images)

CASE STUDY

Malaysia

Population: 32,365,998[36]
2030 Projection: 36,100,000[37]
Size: 328,550km^2 [38]

MALAYSIA'S MOTORCYCLE ONLY LANES: ADDRESSING TWO-WHEELER ROAD SAFETY

Over 80 percent of households in Malaysia own at least one motorcycle, making motorcycles the second most popular mode of transport in the country.[39] With significantly lower costs compared to four-wheelers and the ability to weave through Malaysia's congested streets, motorcycles are a popular mode choice. In fact, in developing countries where motorbikes are commonly used, two-wheelers may demonstrate higher capacity per lane than BRT or light rail. Despite their benefits, motorcycles pose significant safety risks on mixed traffic roads in Malaysia. In 2020, the Malaysian Institute of Road Safety (MIROS) Research reported that 67 percent of fatal roadway incidents involved motorcycles. In response to these high numbers, the Malaysian government is paying greater attention to safety measures for motorcyclists with plans for greater segregation between motorcycle traffic and cars along major roadways.

In the early 1970s, as part of a World Bank project to support motorcyclist safety, Malaysia's first motorcycle lane was constructed along its Federal Highway Route 2, connecting Kuala Lumpur to the Subang International Airport over a 16-kilometer, guardrail-separated path. Grade-separated interchanges were used to connect the track with the main roadway, providing safe access for motorcyclists. In the 1990s, the lane was extended as part of the improvement program to the two-lane expressway connecting the Subang International Airport to the cities of Shah Alam and Klang. Just six months after the opening of this stretch of the motorcycle lane, motorcycle accidents along the route significantly dropped by 25 percent.[40]

Numerous federal roads in Malaysia now include designated motorcycle lanes that separate two-wheelers from car traffic and, along certain routes, provide shelter stations that offer motorcyclists relief from the elements. These motorcycle lanes are typically about half the width of conventional expressway lanes, running alongside, yet typically protected from, car traffic and are positioned to the left of roadways. While some lanes are simply bound by mere striping, most are physically separated from expressways by a guardrail and feature dashed line striping to allow riders to pass one another along certain spans. Although poor conditions like dark tunnels, occasional unmarked bumps, and sharp diversions on the motorcycle lanes demonstrate a need for improvement, use of these lanes have reduced fatal motorcycle accidents.

Malaysia has more plans in store for the future of two-wheeler transport. Malaysian transportation research groups and experts have been advocating for the nationwide implementation of motorcycle lanes to be included in the five-year 12th Malaysia Plan starting in 2021. In addition, the Transport Ministry along with MIROS and the Road Safety Department are encouraging the use of more sustainable electric motorcycles with lower speed limits and a lighter carbon footprint. As Malaysia continues to formalize the operation of two-wheelers within their infrastructure, the country represents a good example of how to develop necessary and safe design solutions as motorcycle use grows in developing urban environments.

Figure P3-20: Separated, dedicated motorcycle lane along one of Malaysia's highways. (Source: Shutterstock)

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