State of Practice Research Memorandum

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NTS CITY OF PHOENIX NEIGHBORHOOD TRANSIT STUDY

Prepared for:
Public Transit Department, City of Phoenix

PHOENIX T2050

AECOM

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LIST OF ACRONYMS

ADA	Title VI of the Americans with Disabilities Act of 1990
ASU	Arizona State University
ATP	Austin Transit Partnership
AV	Autonomous Vehicle
CapMetro	Capitol Metro
CDL	Commercial Driver's License
CDOT	Colorado Department of Transportation
CNG	Compressed Natural Gas
COP	City of Phoenix
CSP	Colorado State Patrol
DAR	Dial-a-Ride
DES	Department of Economic Security
DMV	Department of Motor Vehicles
DRT	Demand Responsive Transit
FAQ	Frequently Asked Questions
FDR	Flexible Demand Response
GPS	Global Positioning Systems
GUS	Glendale Urban Shuttle
MaaS	Mobility-as-a-Service
MCTX	Montgomery County, Texas
MERGE	Manage Explore Reserve Go Everywhere
MUTCD	Manual of Uniform Traffic Control Devices
NHTSA	National Highway Traffic Safety Administration
PTD	Public Transit Department
QoL	Quality of Life
ROW	Right-of-Way
RTC	Regional Transportation Commission
RTD	Regional Transportation District
SAE	Society of Automotive Engineers
SUV	Sport Utility Vehicle
STAR	Specialized Transportation Access Routes
TEP	Transportation Engineering Plan
TNC	Transportation Network Company
UT	University of Texas
UTA	Utah Transit Authority
VM	Valley Metro
WAV	Wheelchair Accessible Vehicle

1. WHAT IS NEIGHBORHOOD TRANSIT?

The City of Phoenix (COP) operates four neighborhood circulators. These services were established to provide neighborhoods of the city with the most basic level of service: short, localized trips with access to areas that are not easily navigated or efficiently served by the larger local buses. The existing circulators are popular within the community, although economic and pandemic driven service changes have encouraged their re-evaluation. The COP continues to receive requests for more circulators in other neighborhoods and has determined it necessary to establish and understand the current state of practice for neighborhood transit available in peer cities across the United States.

The requests for new circulator services are noted and considered however, with the reality of limited resources, the City of Phoenix Public Transit Department (PTD) commissioned this study of alternatives to the transit circulator model. While many of the options included involve transit agency participation, several do not. PTD will rely on the tools developed in this document when considering new or improving existing neighborhood transit services. It is hoped that this document can also serve as a resource to empower communities to find creative ways to meet their neighborhood transit needs.

Neighborhood transit is the compilation of transit modes and services that provide local transit coverage and facilitate connections to the greater transit network. The real-time response, monitoring, and variety of transit services options are rising to meet emerging passenger expectations, commuter trip needs, and transit agency efficiency goals. Strategic siting of services is driving ridership growth for returning passengers who find demand-responsive transit both timely and reliable.

Neighborhood transit services range by community, marketing approach, and the specific needs of the location in which they operate. The most common neighborhood transit service names are circulators, flex service, call and ride, dial-a-ride, on-demand service, on-call, and micro-transit. Regardless of the name, the services offered in the neighborhood transit portfolio include variations of route-based and zone-based services. A key characteristic of a neighborhood transit service is the stop configuration, where a transit vehicle stops and boards riders, and ride request format, which is how the rider requests a ride. Neighborhood transit service provides users the ability to arrange trips with multiple modes including shuttles, micro bus, or traditional buses, which can be partnered with privately operated on-demand services to adapt to a range of travel needs. Common among all service types, regardless of the name, stop configuration, or ride request format, is the ability to connect neighborhoods with the larger transit network, improving overall connectivity for residents.

No matter the service, all options offered by or in partnership with transit agencies must comply with Title VI of the Americans with Disabilities Act of 1990 (ADA). This includes guidelines for equitable access for persons in wheelchairs or other personal mobility impairments. Equitable access also applies to fares, payment methods accepted, and ride request options available. Neighborhood transit service can play a vital role in meeting community needs with some variations largely modeled after the flexibility of paratransit

services with the efficiency of technological advances have made possible. Neighborhood transit service is part of a larger sharing economy movement, leveraging technological innovations and offering municipalities the opportunity to organize and re-define connections among communities and people.

The objective of this document is to present a comprehensive overview of neighborhood transit service options currently being implemented in various cities. The seven neighborhood transit service types – on-demand exclusive services, on-demand pooled services, route-based services, zone-based services, bike-sharing and e-scooters, employer-based commuter services, and property-based services – are reviewed to understand the key components of the service type operations, environments, and features. Case studies and pilot projects are then shared to better understand how neighborhood transit options are being employed in peer cities. To conclude, case studies of currently operating fixed-route circulators in the Phoenix are summarized for their practical applications and lessons learned.

2. SERVICE TYPES

This section reviews the characteristics of common neighborhood transit services used across the country. The service types are classified based on their operating characteristics such as service operations, service environment, and their features. Following that, is a summary of the pros and cons of service for each service type. Finally, this section discusses the best practices for implementing such services in Phoenix. The following definitions are the eight key factors for assessment of a neighborhood transit service:

Service Configuration: This is how the service type meets the ridership needs. Fixed-routes are traditional services with a defined route. Request stops can be an added feature to fixed-route services. Zone-based routes operate in a pre-determined zone under boundaries and with options for pick-up and drop-off throughout the prescribed area. Configuration can also be demand-responsive meaning the response to a ride request is immediate or stipulated to meet that specific passenger's personal or small group needs. Frequency of service is included with service configuration.

Stop Configuration: The number of origins and destinations included in the service type trip. Stop configuration has a great impact on the efficiency of a service type to serve individual needs with immediacy or group needs with moderate timelines.

Service Environment: The range or area covered by the service type.

Ride Request Format: The ride request format is a service characteristic that varies by operator platforms. Formats are distinguished between options for pre-arrangement or no pre-arrangement prior to trips. The ride requests are received through online applications, designated stops, call and ride, or street hailing.

Fare Collection: The fare collection can take place through online applications, traditional fare box collection, cash or card, and transit tickets/passes.

Access Requirements: The access to the service is signified by the pre-determined pick-up and drop-off locations and their physical access attributes. This includes necessary right-of-way (ROW) allotments, ADA compliance, signage and other physical considerations for access to the service.

Target Riders: The type of needs that are met for the passengers by the service type. This includes neighborhood, transit, or activity center connections. Additionally, if the type of ridership need is immediate and a direct service or can join a group of passengers for a moderate timeline until arrival at destinations.

Technology: The impacts, restrictions or benefits technology brings to the service type. This includes virtual access and equity considerations for service type offerings.

2.1 On-Demand Exclusive Services

On-demand exclusive services are separate sequential rides of a single vehicle with each user having the choice of the destination **(Figure 1)**. The most traditional model of this service is a taxi. In the recent decade, Transportation Network Companies (TNCs), most prominently Uber and Lyft, have entered the market with privately-owned, non-commercial vehicles and operators. TNCs provide application-based transactions and coordinated ride-sourcing. The primary innovation has been the abundance of privately contracted drivers contributing their personal vehicles and ease of access for requesting a ride and matching a passenger and vehicle with real-time ride arrival and location selection. The passenger is notified when and where the ride will begin and end with the ability to rate their level of satisfaction.

Figure 1: Uber and Taxi

Service Operation

This service is demand-responsive to the needs of the passenger. The TNC vehicle or taxi directly responds to the passenger's location for pick-up and drop-off. For online application-based services, the pick-up and drop-off locations are selected by the passenger prior to ride request confirmation.

Stop configuration of this service is one-to-one, meaning that there is one origin and one destination per trip. The origin and destination are specific to the passenger's specific needs. Due to this individual flexibility, the price of service in the private market is more costly than route-based or zone-based services.

Service Environment

The coverage area for on-demand exclusive services is at the range prescribed by the passenger. The service can make the neighborhood connections necessary for further use of the network at large but can also be utilized for longer trips. TNC operators and taxis typically remain in proximity of activity centers and areas with high volumes of potential riders such as airports, shopping malls, and business districts.

Service Features

Ride Request Format

Ride requests for on-demand exclusive services are performed by the passenger. Traditionally, in this model, the passenger would call to schedule a taxi or a cab prior to or for immediate service. With recent innovations, made possible by smartphones, the passenger can order a TNC vehicle via online applications. The exclusivity and modern approach of this service dictates that the ride requests are accounted for in real-time and provide passengers with monitoring of inbound TNCs.

The integration of on-demand services into transit agency offerings has been made possible by data-sharing agreements that provide equity and access to the service type for all potential passengers. Subsidies in formal agreements between transit agencies and TNCs have provided greater accessibility with prepaid cards, ride request call centers, and transit Mobility-as-a-Service (MaaS) phone applications. MaaS is a recent development in the transit industry where agencies provide a single and consistent platform for the public to access service. The whole portfolio of services offered by the agency is complemented by the integration of data, trip planning, payment tools, booking, real-time information, networking, public transport design integrated with private contracted services, managing ridesharing services, and data quality assessment and consumer feedback.

Fare Collection

Fare collection can take place in multiple ways. For taxis, the traditional fare collection methods include cash and credit card. For TNCs, this function is completed on an online application particular to the service company. The passengers download and subscribe to the TNC's online application and link their credit card or other online payment platforms to the account. Uber has recently launched ride-pass programs for monthly subscriptions to customers for $24.99 a month in pre-determined zones.

Access Requirements

As a curbside service, prioritizing curb access is essential to safely reaching the passenger. The physical access to these vehicles is completed by drivers or within pre-determined boarding locations for large developments, such as airports, shopping malls, and special events, as seen in **Figure 2**. Administration of access and ownership of right-of-way are typically at the municipal level. To ensure curbside pick-up and drop-off, locations are typically designated and coordinated with municipal planning departments. TNCs may have lower levels of curb access than those operating under pilot programs or partnerships with transit agencies and cities. This service type's ability to serve ADA passengers is constrained by contracted employee training and the type of private vehicle used.

Figure 2: Rideshare Pick-up Zone

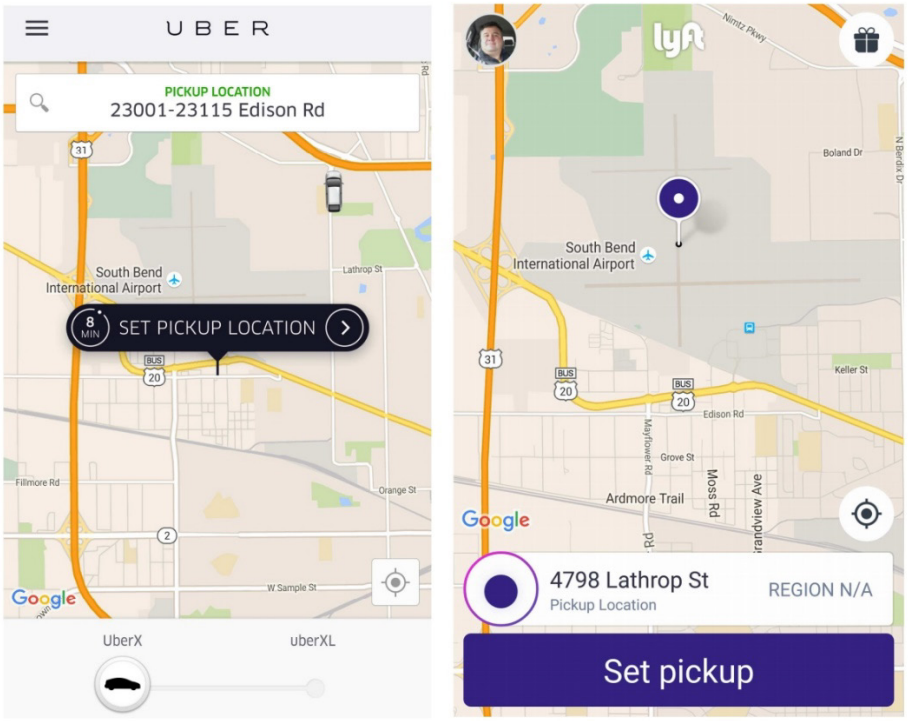
Target Riders

Target riders for this mode are passengers who need immediate or scheduled trips and/or people who are financially positioned to afford exclusive service options. Ensuring ride availability for disabled passengers with Wheelchair Accessible Vehicles (WAV) and with equivalent response times can be a challenge but has been adapted for with call centers and offering prepaid debit cards. Transit agencies may also engage a third-party WAV provider, in addition to TNCs. The passenger capacity ranges from one to six, with one individual requesting and paying for the service.

Technology

The reservation and tracking of vehicles through an online application are key technology components of on-demand services. The presence of a global positioning system (GPS) device in privately-operated vehicles pairing with the passenger smartphone is the primary function that enables ordering on-demand transit for this service type. Beyond matching passengers with drivers, this technology enables virtual billing and passenger feedback systems. Examples of TNC application platforms are shown in **Figure 3**.

Figure 3: Online application interface for Uber and Lyft



Virtual access to on-demand services requires the passenger to own a smartphone/phone plan and have a linked credit card or online banking application. This is a significant consideration in the equitable access of the service for demographics who cannot afford a cellular plan with internet or the cost of a smartphone. However, for those without this technology, accommodations can be built into a partnership contract with transit agencies by

including call centers to schedule rides for passengers and options for a third-party provider who accepts cash.

Pros and Cons of Service

Table 1 lists the pros and cons of utilizing on-demand exclusive services.

Table 1: On-Demand Exclusive Services Pros and Cons

Service Type	Pros	Cons
On-Demand Exclusive Services	• Service is maintained and accounted for by private entities • Individual ride • Expedient and real-time response	• Expensive, individual cost • Privately held data, unless in contracted partnership • Market response to jurisdictional equity • ADA access limitations • Technology restrictions for those without smartphone/credit card

Similar Operating Services

Valley Metro (VM), in partnership with Waymo, an autonomous vehicle (AV) company, began a pilot program in August 2020 to leverage cutting-edge technology to increase access to the transit network. The program will focus on first/last mile connections to transit stops, transit centers, and park-and-rides with potential to augment other VM on-demand services. This service can become a safe and cost-effective way to move people and provide additional paratransit service.

Best Practices for Implementation in Phoenix

PTD could provide first/last mile connection services in conjunction with TNCs, similar to the VM and Waymo partnership. This service could operate in lower density areas of Phoenix with little to no transit access and feed riders into the greater transit network while also providing paratransit alternatives. For fully privately run on-demand service, like Uber or Lyft, cost can be prohibitive to some riders. A public/private partnership could provide a subsidized version of this service type to allow for universal access.

This service type could eliminate costly fixed-route feeder lines and mitigate "transfer penalties" between feeder routes and the main transit network. Areas of low-density development may require agencies to operate routes with low productivity and low farebox recovery ratios. As this service is on-demand, it has the potential for significant cost savings over fixed-route services provided in low density areas with substantial operations costs but little ridership.

Agency operated paratransit, dial-a-ride (DAR), and other forms of non-emergency medical transportation services usually require at least 24 hours advanced notice to reserve a ride, and often these services provide a window for arrival times, leaving riders with lengthy and

unpredictable wait times. Low ridership and vehicle utilization also often make these services the most expensive for transit agencies to operate on a cost-per-ride basis.

Both time and cost inefficiencies could be solved by implementing a single on-demand exclusive service to provide responsive service. However, capital costs to acquire fleet vehicles, including those that are ADA compliant, may be prohibitive.

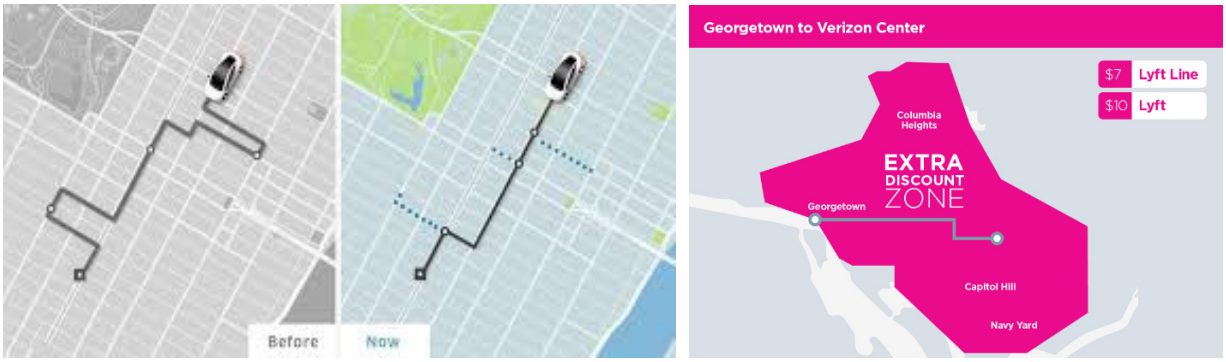
2.2 On-Demand Pooled Services

This service type is opted into by two or more unrelated parties sharing a common destination area who choose to split a single ride and cost. Also known as dynamic carpooling or ride-splitting, the pooled service is heavily supported by privately owned application-based services that mediate between multiple passenger destinations to combine rides efficiently. This service type is an option on most TNC service applications. The ride request format is demand-responsive and routed to "zones" for multiple passengers.

Service Operation

Service configuration for on-demand pooled services is demand-responsive and zone routed. The emergence of TNC sub-applications and interfaces, such as Uber Pool and Lyft Line **(Figure 4)**, have enabled users to find routes particular to a destination zone. Exclusive riders can change their transit ride service type to "pooled" in the TNC's online application interface if they are willing to join a stranger in a concurrent ride. Passengers are notified it would cost less for a combined trip. This interface and sub-application allow for passengers to make immediate decisions about the type of trip priorities they have.

Figure 4: Uber Pool and Lyft Line Operations



Stop configuration for on-demand pooled services is many-to-many. Many-to-many is the operational scenario where the provider of the service does not place boundaries on the types of trips they accommodate. For the function of pooling services, there may be several origins and destinations for passenger trips overlapping with one another making the route distinctively created for the efficiency of serving multiple origins and destinations.

Service Environment

Traditionally, a driver with the knowledge of an area, would discern the optimal route for multiple passengers. With recent technology, an algorithm determines the best route for the

driver to take for pooled services. The service type environment is like on-demand exclusive service types that are focused on activity centers and primary areas of business. The coverage is determined by the passengers, but the increased efficiency of multiple passengers extends the viability for the TNC and taxi range.

Service Features

Ride Request Format

Ride requests for on-demand pooling depends on mode type. Taxi ride splitting is an agreement between passengers or pre-determined by the taxi company before pick-up. For TNCs or taxi e-hail applications, the interface allows users to select pick-up and drop-off locations. If a preference for a pooled ride service has been selected, then the software's algorithm will delineate the best order for pick-ups and drop-offs of concurrent and consecutive passengers.

Fare Collection

The fare collection for on-demand pooled services is conducted via online application for TNCs. Taxis are often outfitted with credit card machines and accept cash. For pooled service, the separation of payment must be defined before the departure, and cost must be appropriately distributed between the multiple passengers. For TNCs, sponsored dynamic pooling is performed via the software's algorithm optimizing route and cost per passenger.

Access Requirements

Similar to on-demand exclusive services, the access for vehicles is completed by drivers or in specific boarding locations. Prioritizing curb access is essential for this service type to safely reach the passenger.

Target Riders

The service is best suited to those who are willing to share a ride for cost savings and have a common origin and destination. This service type usually operates in densely populated areas such as downtowns, airports, train stations, or event centers. The typical passenger load is two to six passengers.

Technology

The technology essential to this service type is the computer software application which connects riders to single trips within a zone or on a common route where an algorithm determines the optimal route. The software reserves vehicles, calculates the fare per passenger, matches passengers to shared rides, and facilitates passenger experience and feedback.

Virtual access to on-demand services is determined by multiple factors. The passenger's ownership of a smartphone with cellular plan and a credit card or an online payment platform subscription is necessary to gain access. These are primary concerns for the equity of this service for those on fixed-incomes or without smartphones/cellular plan.

Pros and Cons of Service

Table 2 lists the pros and cons of utilizing on-demand pooled services.

Table 2: On-Demand Pooled Services Pros and Cons

Service Type	Pros	Cons
On-Demand Pooled Services	• Service is maintained and accounted for by private entities • Pooled concurrent rides • Improved efficiency of trips • Cost split	• Relatively expensive • Privately held data, unless in contracted partnership • Market response to jurisdictional equity • ADA access limitations • Technology restrictions for those without smartphone/credit card

Similar Operating Services

VM operates a vanpool service in the Phoenix metro area. This service is provided through their "Share the Ride" program where VM will provide a van for a group of six to 15 people who all work for the same employer and live in the same general area. It is up to the group to decide pickup/departure locations, times and who will be responsible for driving; a driver and two alternates must be present during vanpool operation. The fare for this service is collected on a monthly basis for fuel and mileage and averages around five dollars per person per day. This service allows the riders to utilize the HOV lane, thus lowering commute time, ease congestion during peak travel times, and aids in lowering vehicular pollutants.

Best Practices for Implementation in Phoenix

PTD could provide this service type and model it after VM's program. Vanpooling options could be marketed to commuters from around the Phoenix Metro area that would prefer this type of service over driving a personal vehicle at peak travel times. Fare collection could be collected weekly, monthly, prepaid, and potentially be employer subsidized.

Additionally, this service type can be used as an alternative to traditional paratransit services. Responsive on-demand service could pick-up riders in a particular area for non-emergency medical trips. This option could eliminate advance notice reservations and long wait times for pick-ups.

However, capital costs to acquire fleet vehicles, including those that are ADA compliant, may be prohibitive.

2.3 Route-Based Services

This service type includes private and public transit services that can be hailed and routed without rider pre-arrangement. Route-based services operate consistently throughout the service hours, with potential for different frequencies during peak and off-peak periods. Stop configuration options include many-to-many, few-to-one, and one-to-one connections. The

ride request format is street hailing which usually occurs at defined bus stops and no pre-arrangement is required to ride. This type of service is comprised mostly of dollar vans **(Figure 5)**, jitney's **(Figure 6)**, and circulators **(Figure 7 and Figure 8)**. The fixed-route transit agency operated circulators are commonly operated on high-frequency routes with a high ratio of stops that may or may not provide deviations. This service type has been piloted in Denver **(Figure 9)** where riders navigate known common pick-up locations with the option of requesting a deviated drop-off stop location. Modern route-based services may have flexible features, such as route or stop deviations for drop-offs but have no online or call center provided pre-arrangement of rides available to passengers.

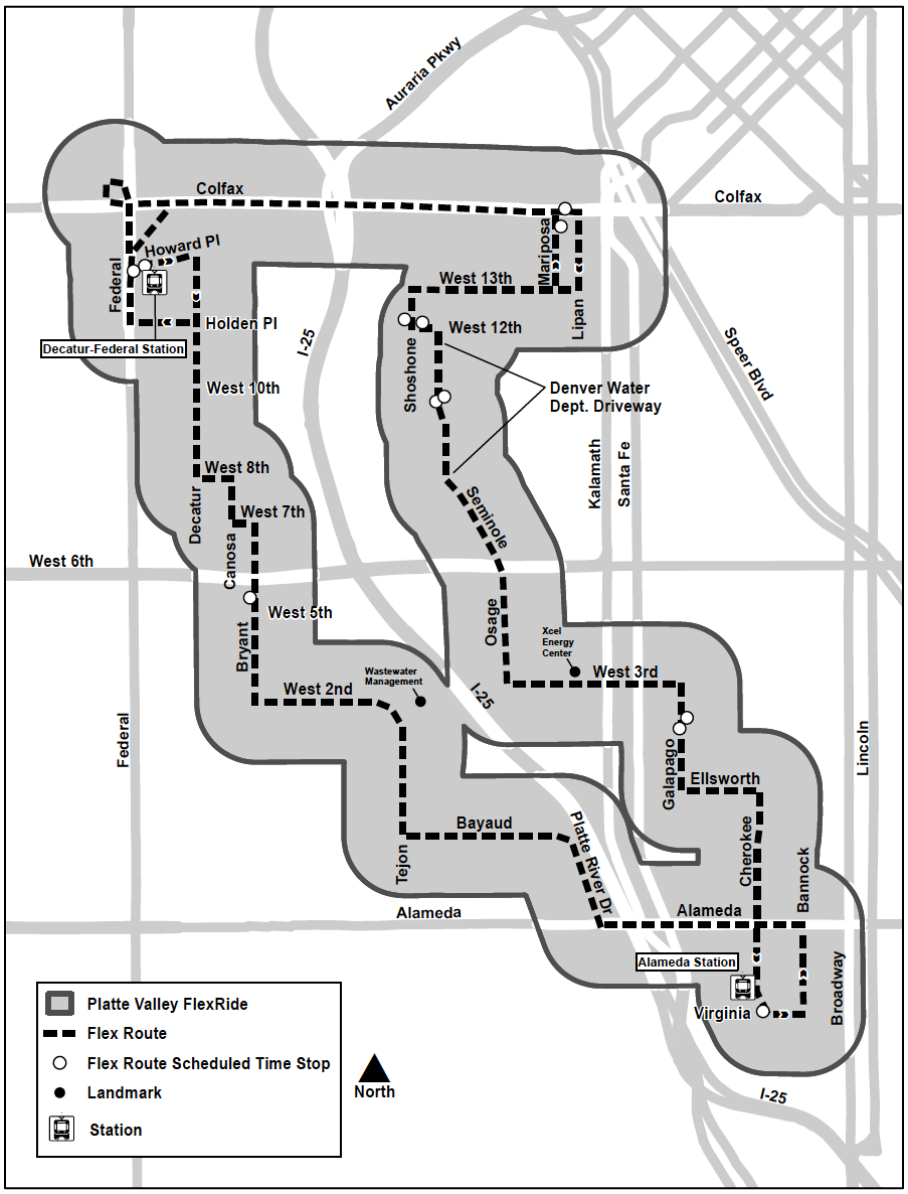
Figure 6: Dollar Van in Brooklyn, NY

Figure 5: Jitney in New York City

Figure 8: Phoenix, AZ DASH

Figure 7: Tempe, AZ Orbit

Figure 9: RTD Denver FlexRide Route



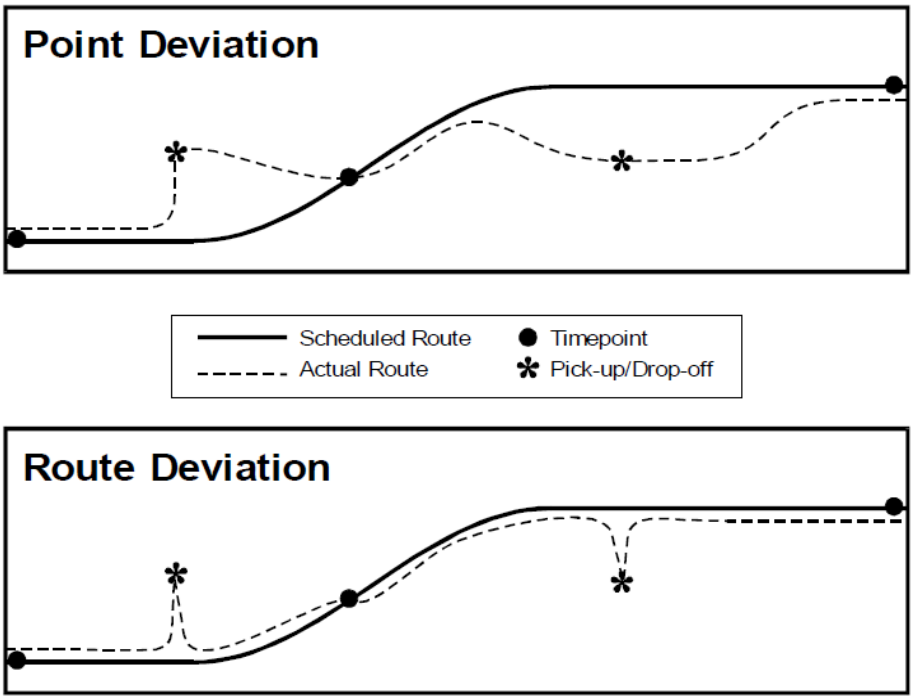
Service Operation

The configuration for route-based services depends on the organization objectives. The traditional route-based services operate on a fixed-route between multiple anchors or stops throughout a neighborhood or activity center. The principal innovation of this service type is the potential point and route deviations **(Figure 10)** for rider drop-offs. This combines a scheduled fixed-route with the capability to adjust to the needs of a passenger. This service type option is dynamic in meeting the passenger needs while re-orienting to fixed-route checkpoints and common paths for street hailing. The deviations usually range within a route buffer from ¼ mile to ¾ mile in compliance with ADA guidelines. Frequency of these services range from 15-30 minutes, with 15 minutes considered optimal.

There are three primary configurations for the number of origins and destinations serviced:

- Many-to-Many: This stop configuration is modeled after traditional looped neighborhood circulators.
- Few-to-One: A few origins and a single destination.
- One-to-One: The service is modeled after jitneys or dollar vans. This stop configuration has one pick-up site with a singular neighborhood or activity center destination for riders.

Figure 10: Point and Route Deviation Service Graphic



Source: Federal Transit Administration (2003) *Transit capacity and quality of service*

Service Environment

The median coverage area for route-based services is 7.5 miles, although service can range from two miles to 30 miles. The dollar vans and jitney services that operate privately are typically located in dense urban cores with transportation to and from specific neighborhoods and/or activity centers.

Service Features

Ride Request Format

The ride request format is based on a traditional street hailing with no pre-arrangement option. Since there is no pre-arrangement, the rider is confined to the established service schedule. This allows for meeting the immediate demand and service needs of riders who board at designated locations.

Fare Collection

The traditional method for fare collection of jitneys and dollar vans is cash only. Presently, some geographic areas including Miami-Dade County, Atlantic City, and Houston, Texas, have licensed jitney companies under chauffeur standards of business. For other public agencies experimenting in pilot projects of flexible services, the fare collection for these services use the same rates, free fare transfers, and collection methods of existing fixed-route services to not incur ADA violations or complaints. The simplicity of mirroring existing practice makes for more cohesive inclusion of services into existing infrastructure.

Access Requirements

The access requirements of route-based services are determined by the stop locations established by the companies and public agencies. The priorities set for access must meet standards for curb-access and necessary right-of-way at the locations for pick-up and drop-off. Public access to the stop locations must be ADA compliant.

Target Riders

Route-based services are geared towards riders who need a neighborhood or activity center transit service and may lack access to online applications for on-demand services. The prescribed and pre-determined stop locations make access to local and regional transit service viable. The flexibility in point and route deviations make the service type adaptable to individual needs or for those who lack access to traditional fixed-route services. Ridership accommodations for this service are six to15 riders per trip for jitneys and up to 30 for circulators depending on the size of vehicle, which can range from minibuses to full-size transit buses.

Technology

Technology is not a key factor for this service type due to traditional stop locations and schedules acting as arrangements for service. Improved systems of this service type could employ vehicle location technology for riders to track the location of the transit vehicle in real time.

The virtual access consideration for this service type is not a challenge for the equity of the service. With knowledge of the route and stop locations, any passenger can hail the transit service without arranging the ride on a smartphone or online application.

Pros and Cons of Service

Table 3 lists the pros and cons of utilizing route-based services.

Table 3: Route-Based Services Pros and Cons

Service Type	Pros	Cons
Route-Based Services	• Many-to-one stop configuration makes most efficient neighborhood/commute connections • Route and point deviation provide origin-to-door service • No technology requirements	• Street hailing can leave passenger without real-time information about service • No pre-arrangement • If privately owned and operated, no access to data collection

Similar Operating Services

This service type in discussed in-depth in **Section 3** of this memo. Cities that have successfully implemented route-based services are Denver with Route 61AV and Las Vegas with Navya AV.

Best Practices for Implementation in Phoenix

Phoenix already operates four route-based circulators: ALEX, DASH, MARY, and SMART. These services connect residential areas, park-and-rides, and business centers to other transit services and high-density areas. The routes can be reevaluated to ensure they are providing a quality level of service required to meet ridership needs.

2.4 Zone-Based Services

Zone-based services are configured for low- to medium-ridership within a prescribed zone of operation. These services can be operated privately, publicly, or in partnership with user-responsive dynamic routes and stop selections. For the public sector, this service type is a district- or neighborhood-based service operating in delineated zones or from anchor points with on-demand or scheduled options, as shown in **Figure 11**.

Figure 11: Denver RTD FlexRide Zone

Private, zone-based service types are application-based and dynamically routes the rider pick-up and drop-off requests. Private companies like Chariot in New York City **(Figure 12)**, or the Bridj/KCATA RideKC program, a partnership with Kansas City, Missouri **(Figure 13)**, provide this type of service where the software computes he most efficient route for meeting multiple rider trip needs. These programs use a model designed to capture ridership by using a "crowd-sourced/crowd-funded" method where potential riders recommend new routes. If enough voters pledge to use a newly proposed route, usually 50, then the route is established on a trial basis.

Figure 12: NYC Chariot

Figure 13: RideKC Bridj Shuttle

The options of vehicle types for this service are multi-passenger SUVs, shuttles, or microbuses **(Figure 14)**. The service design lowers capital cost in labor, units, and maintenance while flexibly meeting needs of transit users.

Figure 14: Houston METRO Community Connector Vehicle

Service Operation

The configuration of the zone-based service varies by the operator. Recent innovations and pilot programs have led transit agencies to explore zone-based services that can travel to multiple stops within a zone and operate from a specific endpoint, typically an activity or business center. Private crowd-sourced platforms, such as Chariot or Bridj, connect passengers from residential areas through a general corridor directed to business districts and transit stops for morning commutes and in reverse for evening commutes. Response times are dependent on service configuration and number of stops but range from ten to sixty minutes with ten to thirty-minute headways considered optimal.

The stop configuration for zone-based service varies depending on the type of service and the entity managing the service. A zone-based service operating under the few-to-few service model would stop at a few pre-determined anchor points, or areas for pick-up, and a few areas for drop-off. In more recent cases of dial-a-ride, zone-based flexible, and application-based ride-hailing, the few-to-few configuration is most common. A few-to-one configuration is where there are multiple origins from multiple riders, but they all share a common destination. The few-to-one operating model typically works best at an airport or university. An example of a few-to-one service is Trip to the Strip, covered in the Las Vegas case study.

Service Environment

The coverage area for zone-based services is focused on neighborhoods operations. The coverage provides access to transit stops, activity centers, or trips within the zone for areas lacking enough demand for traditional fixed-route services. The area coverage is matched to neighborhoods with transit needs greater than currently being met by fixed-routes and those which stand to increase transit ridership the most. The coverage area is determined by the level of need in the zone and distance to the greater transit system.

Service Features

Ride Request Format

The ride request format is based on the existing interface with transit users. Private companies use online applications and websites to interact with customers. Public agencies coordinate ride requests through online applications or telephone booking platforms.

Fare Collection

Zone-based services are paid for through credit cards, online applications, tickets, or transit passes. For public offerings of this service type, payment options should mirror the larger transit system. In a private/public, fare collection could still vary, depending on the technology available but should be at par with the rates of other public transit modes.

Access Requirements

Through public agency coordination, ROW and curb access can be allocated allowing connection for zone-based service vehicles. Signage and stop locations should follow the same design guidelines as fixed-route services. Private companies should operate by accessible curb locations and adhere to traffic management regulations. If a partnership between a private company and a public agency is established, ROW access and signage can be coordinated.

Target Riders

Target riders for zone-based services are those who need first/last mile connections to transit services, or access to local community amenities and/or government services. Zone-based services can also create small neighborhood connections that are too large to cover by active transportation modes but are not efficiently serviced by fixed-routes. For private sector services, the target riders can be defined by those who crowd-sourced the ideal route origins, stops locations, and destinations. These services are usually more expensive to use than

standard transit but also travel more direct routes. This service type has been deployed across multiple cities that were previously failing to meet target ridership in low-density areas. The typical passenger loads are six to 15.

Technology

The role of technology for this service type includes online applications and existing fare collection methods. The online applications used by companies like Bridj and Chariot provide reservations and real-time vehicle tracking. This technology also allows riders to determine their routes based on demand. Billing and fare collection can also be automated in software applications. The ability for applications to track vehicles and predict arrival times gives passengers better control over travel times and increases confidence in the system.

Virtual access to zone-based services can be impacted by the rider's ownership of a smartphone/cellular plan and a credit card or other online payment platform, as these are essential to subscribe to the service. Access to internet and mobile banking are primary concerns for the equity of this service for those on fixed-incomes or without smartphones/cellular plan. This can be addressed by integrating transit passes as an accepted payment method.

Pros and Cons of Service

Table 4 lists the pros and cons of utilizing zone-based services.

Table 4: Zone-Based Services Pros and Cons

Service Type	Pros	Cons
Zone-Based Services	• Few-to-few stop configuration makes most responsive neighborhood connections • Online application for ride hailing, billing and rider feedback is innovation space for public transit • Zones are most flexible to rider needs	• Flexibility of service is only financially prudent in a particular urban context • Accounting for jurisdictional equity of zone placement is difficult • Technology restrictions for those without smartphone/credit card

Similar Operating Services

This service type is discussed in-depth in **Section 3** of this memo. Cities that have successfully implemented this service are Houston with Community Connectors, Salt Lake City with UTA on Demand by Via, and Austin with Pickup.

Best Practices for Implementation in Phoenix

Zone-based services are best suited to operate in the areas of Phoenix that have minimal transit connections available and where there is a demand but not enough to justify fixed-route service. This service type could provide transport from anchor points in residential communities to integrated transit network stops, business centers, and to the general

downtown area. Riders may find this type of service appealing as stop deviations may provide more direct routing for specific destinations.

2.5 Bike-Sharing and E-Scooters

Bike-sharing and e-scooters **(Figure 15)** are the most recent development in neighborhood transit mode options. These modes are technology-enabled with GPS and internet connections providing real-time authorization for use and fare transactions. The platforms are either smart-phone application-based or keypad locked. Additionally, bike-share programs can run as dock-based systems **(Figure 16)** where riders must ride to and from pre-determined locations or dock-less self-locking storage units that are free-floating across a city.

Figure 15: ASU Scooter Parking

Figure 16: Phoenix Dock-based Bikes

Service Operation

Bikes and e-scooters are chosen by riders identifying unit locations or through a company's phone application or website. Docked bikes can be located at docking stations, whereas dockless bikes, or free-floating bikes can be located on sidewalks or in parking lots and have electronic self-locking devices. The stop configuration for this service type is one-to-one with a single origin and destination.

Service Environment

The coverage area for bike-sharing and e-scooters is variable by the type of infrastructure available and the area they are designed to serve. There are two configurations of bike-sharing:

- Dock-to-Dock: Bikes that are unlocked from a docking location at pick-up and relocked at drop-off docking location. The location of docking stations determines the area coverage.
- Dockless: The coverage area is determined by the range the rider chooses. Dockless bikes need not be returned to the docking stations, leading to uneven distribution of bikes across the city. Companies are typically required to undertake equal redistribution of bikes.

For e-scooters, the maximum area that they can cover is limited by the battery life. On an average, the scooters can travel about 15-20 miles on a single charge. Further, the companies are typically required to collect, charge, and redistribute these e-scooters to various stations.

Service Features

Ride Request Format

The ride request format of this service type is at the company's discretion. There is no arrangement prior to the immediate need of the rider and locating the bike/e-scooter. For online application-based services the users can reserve a bike or e-scooter when they are in a pre-determined distance to the bike or docking station.

Fare Collection

Fare collection is variable on the type of mode. If the mode is a dockless bike, it has a card receptor that enables the rider to insert a card and pay for minutes or on a company supported online application. Station docked bikes have kiosks to purchase time on a bike and give a passcode to remove the bike from the station. E-scooters transactions take place on the company's online application.

Access Requirements

Curb space and ROW are a specific challenge for this mode. For dockless bikes, the drop-off location is the choice of the rider, with most users leaving bikes/e-scooters on sidewalks. Municipalities are already devising ways to mitigate this issue. This is especially needed at transit stops and stations, or high traffic areas, to ensure these modes do not impede pedestrian movement or block access for people with disabilities. One mitigation measure is geofencing, which is technology-enabled remote slowing and halting of e-scooters when outside of operating boundaries or in no-ride zones. Geofencing paired with designated parking locations at the perimeter of no-ride zones encourages responsible use. For dock-based bikes, a public/private partnership between cities and TNCs determine the appropriate location and number of bikes.

Target Riders

The target riders for these services are those making transit connections, short geographic trips, or visiting a city without access to a personal vehicle. These services are common in high-density areas where many short trips are made between activity centers and neighborhoods.

Technology

Bike-sharing and e-scooter services are heavily technology-dependent. Docked station bikes are managed through kiosks, GPS units, or keypad locks. The dockless bikes have similar GPS units for bike location, unique ID, and keypad locks for billing. The e-scooter applications support reservations and tracking of the units. Redistributing the bikes is based on ridership data for specific areas.

The riders must have the appropriate card or online application to access the service. It is available to the public to use bike-sharing services if they have a credit card for the purchase of minutes. For e-scooters, access to the service is determined by ownership of a smartphone and access to internet to perform the transactions.

Pros and Cons of Service

Table 5 lists the pros and cons of utilizing bike-sharing and e-scooter programs.

Table 5: Bike-Sharing and E-Scooters Pros and Cons

Service Type	Pros	Cons
 **Bike-Sharing and E-Scooters**	• Individual access for first and last mile connections • Origin-to-door service • Service is maintained and accounted for by private entities • Online mobile application accessibility	• New service type without regulatory experience • Low accountability of riders • Sidewalk and access inhibitor if not parked appropriately • Technology restrictions for those without smartphone/credit card

Similar Operating Services

The privately operated GRID bike-sharing program is currently running in Phoenix, Tempe, and Mesa. Over 1,000 bikes are available to rent at any of the 100 stations located around the downtown areas, college campus, and along transit lines. The service is accessible through the Social Bicycling app. Riders can reserve bikes ahead of time or pick one at a station by inputting an account number and key. Fares are charged by the minute and collected through the app via a linked credit or debit card.

BIRD e-scooters are available in Tempe and operate in a similar manner to GRID bikes. An app is required to register an account to access the scooters and fares are charged and collected through the app via linked credit/debit card.

Theft or damage to the bikes and scooters have been reported as well as units being left on sidewalks in a haphazard manner or not returned to docking stations.

Best Practices for Implementation in Phoenix

PTD can implement these services similarly to the GRID and BIRD programs but will need to provide a different payment structure for Title VI populations. A cash or prepaid card option could be implemented at station locations. Docking stations will need to be readily accessible to potential riders while not infringing on pedestrian right-of-way.

Capital costs, thefts, and damages can make this service type difficult to launch and effectively operate. Other barriers to these services are public opinion. Residents of many cities find e-scooters and rentable bike as impediments on roads and sidewalks.

Potential public/private partnerships could ease the cost burden and provide a direction on how to effectively operate these services alongside the transit network. Potential TNC operating experience and contributing funds could aid in conducting a successful bike-sharing and e-scooter program.

2.6 Employer-Based Commuter Services

Employer-based commuter services **(Figure 17)** are often contracted services provided by large employers. Commuter shuttle networks help employees make connections to transit or take employees to their residential areas. This function can work as a business-oriented connection for commuters between places of work, transit stations, and home.

Figure 17: Microsoft Commuter Shuttle

Service Operation

The service configuration is fixed-route where scheduled services make an entire journey between home, workplace, and transit connections. The request stop addition to this service type is for adaptability in cases where commuters may make stops at other businesses or approved locations.

The stop configuration for employer-based commuter systems is for a range of single, few or many origins of pick-up to a single destination. This may vary depending on the service sponsor and the managing organization.

Service Environment

Employer-based commuter services operate in a range determined eligible by the sponsor of the services. These services can be organized by employers at a discounted rate and thus may have range limits to ensure the productivity of the service. This coverage is determined by the number of commuters serviced in a direction and how far the service must go to reach a transit connection or place of residence.

Service Features

Ride Request Format

The ride request format is dependent on the organization sponsoring the service. Pre-arrangement is optional for ride requests because this is a scheduled service. It is dependent on the sponsor organization to meet the needs of the commuter base.

Fare Collection

The fare collection for this service takes place in one of three ways. First, the ride may be heavily subsidized or free and advertised as a benefit to the employee during recruitment. Online applications can also be used for the service if it is contracted by a dedicated provider who supports online interfacing and billing. Finally, a ticketing service may be made available for a large-scale system.

Access Requirements

All commuters of this service are employees of the company sponsoring the service. The ability of the company to offer the service as an incentive or amenity is solely available to employees of the company.

Physical access to the service is determined by the employer's access to curb space. If service is contracted through a company, adequate curb space is a necessity and a legal consideration to ensure safety for boarding, departing, and traffic management.

Target Riders

The target riders for the employer-based commuter service are employees of the company sponsoring the service. The target ridership for this service type is six to 30 passengers.

Technology

The role of technology is organizing the route with an online application or subscription to the service. Billing can also take place on an online application where users have an account like Lyft or Uber to pay for the service.

Pros and Cons of Service

Table 6 lists the pros and cons of employer-based commuter services.

Table 6: Employer-Based Commuter Services Pros and Cons

Service Type	Pros	Cons
Employer-Based Commuter Services	• Ridership is secured and pre-arranged ridership • Incentivized reduction in single occupancy commuting • Comfort with known trip partners • Technology enabled booking and payment	• Employees only • Privately organized and therefore not much information is shared about the service • Exclusive curbside pick-up/drop-off may not be available, requires coordination with municipality if privately operated

Similar Operating Services

The Microsoft Commuter Shuttle is a part of the Microsoft MERGE (Manage Explore Reserve Go Everywhere) transportation system in the Puget Sound. A vast network of shuttle buses currently operates between residential areas, transit centers (including two located on the Microsoft campus), and buildings within the campus. The service is by-reservation and runs on a set schedule. At present, the shuttles are used by 43 percent of the Microsoft workforce commuting from home or connecting from transit services.

By 2023, the MERGE system aims to raise commute to work ridership to 50 percent and to provide comprehensive services to all work-related travel. This will include inter-campus, airport, and other business-related trips. The system will also connect to the greater Sound transit bus, light rail, and vanpool network. Further, the service is looking to integrate multimodal options with a bike shuttle to provide transport from Seattle to the Microsoft campus in Redmond for cyclists.

These services are provided through the MERGE app and are free to all full-time employees.

Best Practices for Implementation in Phoenix

Phoenix could partner with large local employers to help provide this service type. PTD could potentially operate specific bus routes from areas where high concentrations of employees live, from transit centers, or park-and-rides and transport riders to their business campuses. These services could be subsidized or fully covered by the employers.

2.7 Property-Based Services

Property-based service is a shuttle or van service that connects identified property tenants, buildings, or residential developments to their transit connection or destination. These shuttles, whether assigned to a single or region of properties, make limited stops and are only responsive to the needs of specific riders.

Figure 18: ASU Intercampus Shuttle

Figure 19: Retirement Home Shuttle

Service Operation

This service is configured along fixed-routes that serve pre-determined stop locations of amenities or affiliated properties. The ability for riders to request stops is unique to the provider.

The property-based service shuttles can operate from single or multiple origins with a single destination terminating the routes service; this is determined by the service sponsor.

Service Environment

The coverage area for this service is dependent on the purpose of the service and is designed by routes to and from properties **(Figure 18)** or to local amenities and transit **(Figure 19)**. The service can be hailed from the property or pre-determined stops and is coordinated with the service provider.

Service Features

Ride Request Format

The ride request format for property-based shuttle services is either by no arrangement, meaning riders can hail the service at a property service desk and ride that day, or they may pre-arrange the service to ensure space is available on the shuttle.

Fare Collection

Fare collection for this service is conducted over an online application, ticket sales, or the service is free. The service may also be subsidized by the property or parent company to lower parking demand or provide the service as an amenity.

Access Requirements

For access to this service, riders must be affiliated with the property in some capacity; either working at the property, staying as a guest, an establishment customer, or have contracted access to the service.

Physical access to this service is privately managed by the service provider.

Target Riders

The target riders for the service are those who are spending time in occupation, leisure, or in official capacity at the property. The typical ridership size for the shuttle service is six to 15.

Technology

The technology incorporated is online application ride-hailing services that may be available in some formats. Other technology includes tickets or property pass scanners for property employees or tenants to access the service.

Pros and Cons of Service Type

Table 7 lists the pros and cons of utilizing property-based services.

Table 7: Property-Based Services Pros and Cons

Service Type	Pros	Cons
Property-Based Services	• Ridership is secured with pre-arrangement or no arrangement • Technology enabled booking and payment • Can be free or subsidized as an amenity	• Affiliated property employees visitors, or tenants are the only permitted passengers • Privately organized and therefore not much information is shared about the service

Similar Operating Services

Arizona State University (ASU) intercampus shuttle buses are available to employee and students alike. There are four shuttles that transport riders between the Tempe, Polytechnic, West, and Downtown Phoenix campuses: the Gold, Maroon, Mercado, and Tempe-West Express. Shuttles run every 15 minutes during the week, every two hours on the weekend, and operate between 6 am and 11:40 pm depending on the shuttle. This service is free and only available to ASU students, staff, and faculty as an ASU ID is required ride the shuttle.

Best Practices for Implementation in Phoenix

Similar to employer-based services, PTD could partner with properties that need direct transit services. Properties such as retirement homes, schools, master plan communities, or areas with low-income housing could be prime candidates for this service type. This service can be operated through fixed-route buses, route-based, or zone-based circulators. Fares can be charged, subsidized, or fully covered by the property entity.

2.8 Summary of Service Types

A summary of all service types discussed in this memo are lists in **Table 8** below.

Table 8: Service Type Summary

Service Type	Area Coverage	Stop Configuration	Service Configuration	Ride Request Format	Fare Collection	Access Requirements	Target Riders
On-Demand Exclusive Services	Rider and driver choice Urban areas	One-to-one	Demand responsive	Pre-arrangement for ride Street hail (taxi) Online application	Online application Cash/card	Pre-determined pick-up locations	Immediate One-time trip
On-Demand Pooled Services	Rider and driver choice Urban areas	Many-to-many	Demand responsive Zone route (general direction)	Pre-arrangement for ride Street hail (taxi) Online application	Online application Cash/card	Pre-determined pick-up locations	Moderate timeline One-time trip
Route-Based Services	7.5 mi Urban areas	One-to-one Few-to-one Many-to-one	Fixed route Request stops Route buffer deviations	Pre-arrangement for ride Street hail (taxi) Online application	Online application Cash/card	Pre-determined pick-up locations	Immediate One-time trip
Zone-Based Services	5 to 30 sq. mi Low-density urban areas	One-to-one Few-to-one Few-to-few Many-to-many	Zone route (general direction) Request stops Anchor points	Pre-arrangement for ride Street hail Online application Call and ride	Online application Cash/card Ticket/transit passes	Pre-determined pick-up locations	Transit connections Activity center connections
Bike-Sharing and E-Scooters	Battery life extent High-density urban areas	One-to-one	Demand responsive Payment for distance	Private charging and siting No arrangement	Online application	Designated parking and docking stations	Tourist Station-to-station connections
Employer-Based Commuter Services	Sponsor dependent	One-to-one Few-to-one Many-to-one	Fixed route Request stops	Pre-arranged No arrangement	Online application Free/subsidized Ticket	Designated loading and alighting	Employees
Property-Based Services	Sponsor dependent	One-to-one Few-to-one	Fixed route Request stops	Pre-arranged No arrangement	Online application Free/subsized Ticket	Designated loading and alighting	Employees and visitors

3. PEER CASE STUDIES AND PILOT PROJECTS

Individual case studies for each service type are discussed below to understand practical application and operating environments. Graphics and maps of service types are included.

3.1 Denver, Colorado

The Denver Regional Transportation District (RTD) is the leader of Demand Responsive Transit (DRT) that services a population of over three million. Denver is a growing city with activities spanning many low-density areas. An essential need of the agency has been to address transit relevance in low-density suburban neighborhoods where fixed-route transit is inefficient. Other needs include serving areas of dispersed travel patterns and jurisdictional equity for regions that provide tax support but receive minimal service. The overall benefit of DRT in Denver has been providing connections to the regional transit system with neighborhood transit modes. To accomplish this, the focus has been on two primary objectives: closing the first and last mile gaps for commuters and community zoned circulation for trips within residential and mixed-use areas.

FlexRide Service

FlexRide **(Figure 20)** is a zone-based bus service that is programmed for certain RTD service areas. The service is open to the public and is available on a first-come-first-serve basis. The primary objective of the service is to provide connections to other RTD bus or train services at stations and park-and-rides. The service also connects passengers directly to shopping malls, schools, businesses, and recreational centers.

Defining factors and service types for the FlexRide demand-responsive transit service are:

1. Many-to-many, many-to-few, on-demand, community-based;
2. Feeder to transit network through scheduled connections;
3. Point deviation (Flex route): DRT with dynamically or regularly scheduled checkpoints; and
4. Route deviation (Flex route): fixed-route with regularly or dynamically scheduled, off-route pick-ups or drop-offs.

FlexRide marketing and branding efforts provided guidelines for understanding demand-responsive transit systems along with fare structure considerations:

1. 70 percent of all transit trips are for commuting to work or school.
2. Service design is based on carrying as many people as possible with an emphasis on checkpoints, frequent cycles, and additional vehicles during peak hours.
3. Fare structure is the same as fixed bus routes. Payment forms include cash, tickets, passes, mobile phone, and smartcards.

4. Only seven percent farebox recovery ratio, but fares are less expensive than fixed-route services.
5. Marketing is more difficult than fixed-route service. Substantial coordination was required with communities and direct promotions.

Contractual agreements and provisions were also noted by stakeholders as pivotal to the success of FlexRide:

1. RTD contracts over half of the bus service and all ADA paratransit; documented savings from reduced garaging, operator labor costs, and maintenance.
2. Contracting service provides greater flexibility and sizing of service.
3. Completely automated scheduling and vehicle management platform.
4. The operator RFP process identified key provisions which included:
   - Requirement of competitive salary and benefits relative to existing market.
   - Staffing is adequate and experienced.
   - Clear and specific description of service.
   - Maximizing competition by not using low bid and focusing on experience of company and staff.

Figure 20: Denver RTD DRT minibus in all FlexRide Zones.

Route 61AV

RTD recently completed a six-month AV demonstration project titled 61AV. Beginning January 29, 2019, and ending August 2, 2019, the project was developed as a collaborative effort to better understand the role of AVs in the future of transit. The joint effort consisted of five partner agencies: EasyMile (the AV provider), Transdev (the onboard customer service and shuttle ambassadors), Panasonic (a co-developer of Peña Station Next), LC Fulenwider (a co-developer of Peña Station Next), and the City/County of Denver Public Works. The partnership

leads were aided with guidance and assistance from three state agencies including the Colorado Department of Transportation (CDOT) AV Task Force, Colorado State Patrol (CSP) and Colorado Department of Motor Vehicles (DMV).

Goals of the Project:

1. To safely introduce an AV on a public roadway in Denver
2. Assess the reliability and availability of an AV shuttle vehicle and its suitability for a transit application
3. Provide "first/last mile" service to/from an RTD bus/rail station
4. Align the interests of multiple stakeholders to advance the project

Service Description:

The route was circular, connecting Peña Station for bus and rail, the Panasonic building, a newly constructed apartment complex, and the Peña Station park-n-ride. The AV route traveled in one direction at a speed of 25 mph as posted in the low traffic "local" level street classification. Warning signs were developed in compliance with Manual of Uniform Traffic Control Devices (MUTCD) that depicted "slow-moving vehicle" along the route to inform public motorists of the potential for a slow-moving vehicle in the area. Signage underwent an approval process with the CSP and CDOT.

Vehicle Description:

The vehicle for 61AV service was an EasyMile EZ10, Generation 1 driverless electric shuttle vehicle **(Figure 21)**. The vehicle can hold ten to 12 people at capacity. According to the Society of Automotive Engineers (SAE), the vehicle operates at a level four of five autonomy, meaning there is no requirement for human interaction and if there is a system failure, the vehicle can intervene on its own. Human manual override is provided as an option.

Figure 21: EasyMile EZ10 Gen 1 Electric Shuttle

Results:

The results of serviceability were an average of 89 percent operation in autonomous mode with a measurement conducted weekly. Technology issues that were identified were primarily due to weather conditions. Falling snow was registered on the AV sensors, heavy rain or streams rising from the street were also classified as obstructions causing service

disruptions. During these events and high winds, the AV vehicle was replaced with a traditional transit vehicle. Heat was a consideration for the electrical power supply. The air conditioner drained the battery more quickly making total run time for the vehicle six hours instead of the regularly scheduled eight hours. No accidents occurred and the vehicle performed "as advertised" with reaction to obstacles faster than the average human response time.

Costs:

The project ran a total of six months with a budget and cost of $170,000. All staff time from project partners was provided as an in-kind contribution to the project with no charge. The out-of-pocket cost for RTD was $16,000. This cost was comprised of regulatory signage/ installation and a portion of operations and management. While EasyMile provided the AV, Transdev reduced the cost for on-board customer service. Fullenwider built infrastructure improvements for ADA compliance, Denver provided sign poles and Panasonic/EasyMile maintained a portion of ongoing operations and management costs.

Lessons Learned:

Stakeholder support is a key factor cited for the success of any AV pilot project. The identification of all stakeholders from the beginning of the project set individual and group priorities to ensure needs are being met. Confirming roles and responsibilities from the onset is pivotal to planning and implementation.

The implementation of innovative technologies takes time and can be broken down into the following four processes:

- **Regulatory** accord for the project meant meeting with the National Highway Traffic Safety Administration (NHTSA), State of Colorado AV Task Force, and local jurisdictions to ensure compliance with approval processes for automated vehicles. Responsibility for meeting the NHTSA for approval was carried out by EasyMile.
- **Contractual** agreements were necessary for RTD and Transdev to ensure a person was onboard for manual override cited in the SAE level 4 of autonomy. Vehicle procurement was at no cost to RTD, and funding was agreed upon before project development.
- **Pre-Planning** included finalization of the route and schedule as a part of the regulatory process and was iterative for meeting jurisdictional agency needs.
- **Implementation** for the project was comprised of infrastructure improvements, first responder training, and operator training for technical aspects of the vehicle, standard transit service training for ADA and dispatch communications, and facility and reporting procedures.

Proactive marketing and communications are critical and should be among the priorities of the appointed steering committee. Marketing information and other communications should be made available to the public through websites, FAQs, media, public relations memos and online applications for real-time information and trip planning.

The budgeting for all necessary project elements is the final highlighted lessons learned from the project. The AV innovation space and landscape is complex and evolving. The magnitude can often be overlooked and thus it is necessary to identify all project costs and revenue sources from the start of project development.

3.2 Houston, Texas

Community Connectors

The Houston METRO operates in a service area with a population of more than four million people. The sprawling landscape of the Houston metropolitan area means the city is facing many efficiency challenges associated with low-density environments. Capturing ridership takes innovative and context-specific techniques to make maximize returns from initial investments. DRT was the solution to reach essential riders in a low-density city such as Houston.

The service design was not measured by traditional market analysis but instead with the following service area criteria:

1. Areas served by fixed-route service but with low ridership and productivity.

2. Areas with high concentrations of older and low-income residents.

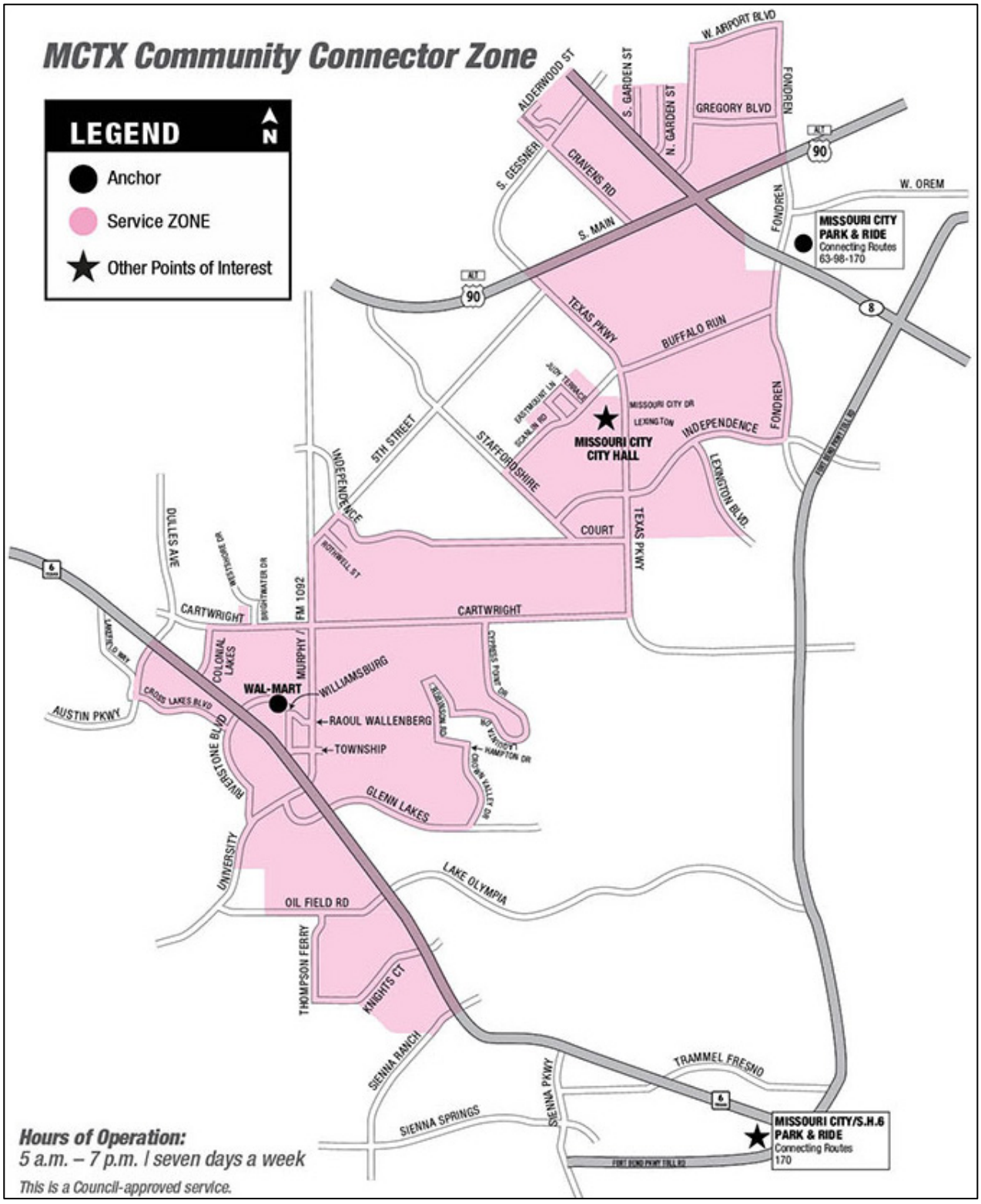
3. Circuitous and disconnected street patterns that make fixed-route service difficult to orient. An example of this is found in the service area map for Missouri City **(Figure 22)**.

4. Poor pedestrian environments where transit connections are more difficult.

5. Areas adjacent to fixed-route service and can provide connections to established and centralized transit stations.

This methodology enabled stakeholders to organize the service according to environmental-specific needs. To secure a trip, riders must board at one of two anchor points or call into dispatch for either individual and specific trips or subscribe for multiple trips.

Figure 22: Missouri City Community Connector Zone



The following points are the key features and lessons learned of the Houston METRO DRT:

1. The original service provider was ARBOC, which was already contracted for paratransit. The service was subsequently brought in-house while the vehicles were owned and maintained by ARBOC. The vehicles are low floor minibuses with 12 seats that were branded with community approved wraps. The buses were small enough to not require a commercial driver's license (CDL).

2. Technology utilized in the DRT service is the Trapeze PASS16 software which enables trip scheduling with live reservation agents. Trapeze Ranger mobile data terminals are used to transmit rider trip information along with GPS for assessing route performance.

3. METRO officials were focused on hiring operators with experience in DRT service. To accomplish the goal of providing a transition for riders that was smooth, METRO on-boarded existing staff or those of the contractor operating the ADA service in the area. This strategic action acknowledged the market awareness that was necessary to fulfill a new and demand-responsive service.

4. Fare payment methods are the same as the fixed-route services allowing for seamless transitions for riders.

5. Funding is drawn from the same sources as those funding the system-wide operation of Houston METRO.

6. Ridership satisfaction ratings gathered from surveys have shown significantly higher scores for demand-responsive service as opposed to fixed-route services operating in the same connector zone areas.

7. The performance metrics of the service have shown low utilization and high cost. METRO had plans to eliminate fixed-route service in the zones to improve DRT service utilization but was not able to due to external political factors. Garnering political support and information are essential to integrating neighborhood transit into the broader network.

8. Houston METRO's self-identified lessons learned are to run pilot demonstrations so critics and the public can better understand and have a positive experience. Secondly, the discontinuation of fixed-route services in connector zones is paramount to reduce redundancy and cost.

3.3 Las Vegas, Nevada

Las Vegas Transit, Regional Transportation Commission

The City of Las Vegas' market is serviced by the Regional Transportation Commission (RTC) of Southern Nevada. The population of the statistical area serviced is roughly 2.25 million. Currently, the RTC has 400 vehicles serving 39 routes meeting the needs of 64 million annual passengers. The commission provides effective multi-modal transportation systems. Part of that mission is reducing congestion in the face of expanding population growth. A measure to achieve that is the implementation of a variety of neighborhood transit options. The commission has focused on transit services, RTC bike share, and the Club Ride program which integrates first mile/last mile connections for businesses and activity centers.

Trip to the Strip

Trip to the Strip is a zone-based pilot program **(Figure 23)**. Trip starting and ending points must be within a North to South running corridor that encompasses the Strip and McCarran Airport. Trip to the Strip is accessible via a mobile application available in both the Apple App Store and Google Play. Users create an account linked to their phone number and credit card information for payment and text alerts. The application functions like that of on-demand TNCs Uber and Lyft. Setting a pick-up is completed with the user's phone GPS location, but the user may alter the "requested pick-up" location. Confirmation of the trip is provided after approval from the agency with an estimated pick-up time. This is a pooled service so individual passengers may be party to the pick-up and drop-off of other passengers.

Figure 23: Trip to the Strip Shuttle

AAA Free Self-Driving Shuttle Pilot Program

From November 2017 to October 2018, AAA sponsored a micro-transit shuttle that operated for 1,515 hours with 32,827 riders. The fully autonomous system was made possible by a partnership between the City of Las Vegas, RTC, and Keolis North America **(Figure 24)**. Keolis was the operator of the self-driving shuttle that was manufactured by Navya. The purpose of the pilot program was to provide the public exposure and help them feel safe about the technology.

Figure 24: Navya Autonomous Shuttle

On November 8, 2017, the AV was in a minor collision with a truck-tractor that was backing into an alley. According to the manufacturer's (Navya) incident report, the shuttle's sensor system was tracking the truck with initial detection of the truck at 45 meters. The shuttle was programmed to stop at three meters from any obstacle and had begun deceleration at 30 meters. At 3.1 meters (10.2 feet) from the truck, the AV was almost at a complete stop when the attendant pressed the emergency stop button. The program was not halted due to the accident and continued through the funding period. A future plan for the GoMed pilot in Las Vegas, Nevada, is still ongoing with a plan for four AVs servicing a connection between Downtown and Las Vegas Medical District.

Club Ride

Club Ride is a commuter service program that residents of the RTC region can register for and choose from a multitude of benefits. Benefits include resources for carpooling connections, vanpooling sourcing, transit connections and discounted passes, bicycling networks, walking routes, riding a motorcycle, telecommuting, and compressed workweek information. All forms contribute to a rewards program feature on a centralized Club Ride rewards mobile application **(Figure 25)**, which is a form of MaaS.

Figure 25: Club Ride online application

Another benefit of membership is the Guaranteed Ride Home program that is specific to emergency circumstances. Club Ride will pay to get you back home, to your car, to a hospital, or your child's school. You can take a taxi/TNC, use public transport, or rent a car (if the destination is more than 30 miles away). Emergencies include personal injury or illness to you or an immediate family member, carpool driver, or vanpool driver or if your supervisor requires unscheduled overtime for you, carpool partners, or vanpool driver. For reimbursement documentation from a registered employer in the program, with receipts, is necessary. Carpool matching is available to program members along with free parking at park-and-ride lots.

Silver STAR (Specialized Transportation Access Routes)

Silver STAR is intended to meet the growing demand for senior citizens' mobility needs in the community. The growing senior population in the area led to the RTC to establish a service that is oriented to the specific context and needs of seniors. Although the service is focused on service for the senior population, it is available to all age groups in the community. The service has twelve routes connecting senior living communities and buildings to regular RTC fixed-routes, surrounding activity centers, and medical centers. The vehicle can accommodate two wheelchairs. The ride request format is conducted online at rtcsnv.com or via telephone.

Flexible Demand Response

Flexible Demand Response (FDR) is a door-to-door transit service. The objective is to connect residents in zones of operation with fixed-route transit stations and shopping centers within three delineated zones. Although the service is available to all residents, it is targeted to capture senior population ridership. The passengers must register for the program and must

make reservations via an online platform or by calling the dedicated call center. The service operates at different times and days of week depending on the zone. The fare is 50 cents for each boarding and exact change is required. Transfers to other RTC transit systems are not issued from the FDR service.

3.4 Salt Lake City, Utah

The Utah Transit Authority (UTA) is comprised of Salt Lake City, Utah and its neighboring sister cities. Those within the boundary work in partnership with UTA to support neighborhood transit in the metropolitan area. The neighborhood transit network supports a broader UTA network of fixed-route bus and commuter rail services. To connect neighborhoods and employment centers, UTA has recently deployed multiple innovations to their neighborhood transit system. A holistic view and plan for transit has been developed with an expanded "frequent transit" service, flex bus, transit information and legibility program, pedestrian and bicycle access, on-demand services, and partnerships with private organizations.

Figure 26: UTA On-Demand Vehicle

UTA On-Demand by Via

UTA is in partnership with a private company, Via, to provide on-demand zone-based pooled service in Southern Salt Lake County **(Figure 26)**. The zone encompasses South Jordan, Herriman, Riverton, Draper, and Bluffdale, totaling about 65 square miles. It is a pilot project and service areas including both light rail, commuter rail, and bus stations and routes bisecting the zone. As a zone-based pooled service, trips must both start and end within the service area. Branded service signs are posted at transit stations to indicate the pick-up/drop-off locations. The ride request format is through an online application by Via or telephone. Payment is processed on the Via application or passengers may use traditional bus tickets/passes available on the UTA GoRide application. The vehicles are large eight passenger vans, and the drivers are permitted to operate the vehicle without a CDL.

Transit Information and Legibility

The digital presence and expectations of riders have grown significantly. At UTA, the focus has been on MaaS, which has led them to procure a simple, intuitive online mobile application

system called UTA GoRide. The model will create a unified portal of access to all mobility or transit services in the region. Creating this platform takes significant coordination of information and software development to ensure reliability. For UTA and the Salt Lake City Area, this means a combination of payment methods, trip planning, and connections between modes, all available within a single platform for passengers. Subscribed users can enter their banking or credit card information and load their account with money that is charged upon trip completion.

Flex Bus

The Flex Bus provided by UTA is a pre-arranged, route-based service tailored towards ADA paratransit needs but also meets the needs of all community members. The service follows a fixed-route and schedule. However, passengers can request a deviation or a special stop up to ¾ mile from the regular route. The deviations are required to be scheduled two hours before the trip and can be made no more than seven days in advance. To operate efficiently, program managers allow for deviations without creating excessive delays for other passengers. To achieve this program definition, the routes are shorter than typical fixed-routes services and the stops are further apart. Individual routes are limited to two deviations per trip. The cost of the Flex Bus is the same as the fare for UTA services but with an additional $1.25 for route deviations.

3.5 Austin, Texas

Capital Metro is the operating transit authority for Austin and its neighboring cities. The transit agency supports a 544 square mile service area with 30 million annual boardings. The total population of the area is 1.27 million. ProjectConnect is an initiative that expands and improves the transportation network integrating light rail, subway, and the bus network in the Austin metropolitan area. The headline of ProjectConnect is that the city is projected to double in population by 2040, with 4,500 arriving in the city every month. The roads cannot grow that fast as the city's population; therefore, the transit system must accommodate the growth and preserve a high quality of life. To accomplish this, Capitol Metro (CapMetro) and the City of Austin have formed the Austin Transit Partnership (ATP), and have established multiple programs and resources including online application for single payment and a route planning system including Pickup, an on-demand service for six zones across the city, MetroRideShare, and university shuttles.

Pickup

Pickup is a zone-based on-demand service operating in six zones in and around the Austin metropolitan area **(Figure 27)**. The service uses an online application and telephone ride request format for individuals who are traveling along similar routes to join in a pooled bus trip. To join the service, riders book a trip with start and end of trip locations and are matched with a service in the zoned area. Estimated times of arrival are provided upon booking the service. Pickup's goal is to pick a passenger up with 15-minutes, but the service states the wait should be shorter than that. Tracking of bus is available in real-time via the Pickup App. The cost of service is $1.25 per trip, the same as fixed-route or rapid bus services.

Figure 27: Pickup by CapMetro Vehicle

CapMetro App

The CapMetro App is an all-in-one mobile application enabling the passenger to purchase tickets, track incoming buses, map a trip, and access a quick pass. Riders can create an account and link their Google or Apple Pay accounts to the CapMetro App. The use of this app provides consistent pricing and service comprehension for cross-mode transfers.

Metro Ride Share

Metro rideshare program is sponsored by Capital Metro and operated by Enterprise. The service type is a vanpool program eligible to groups of five to 12 riders with a month-to-month lease agreement including insurance, maintenance, and 24-hour roadside assistance. This program is supported by Guaranteed Ride Home for emergency situations and groups receive a $500 per month subsidy. The actual cost paid by vanpool members is determined by vehicle type, commute distance, group size, fuel prices, and tolls.

University of Texas Shuttles

The University of Texas (UT) shuttles are structured as a neighborhood circulator connecting the UT campus with the surrounding neighborhoods. The system is comprised of two separate routes operating at a high frequency with a 15-minute headway. The service is free to UT students, faculty, and staff. The general public is permitted to ride the service but must pay a local fare.

3.6 Summary of Case Studies

Table 9 summarizes the case studies discussed in subsections **3.1** through **3.5**.

Table 9: Case Study Summary

Transit Agency	Name	Start Year	Service Type	Frequency and Strategy	Lessons Learned
Denver RTD	FlexRide	Call and ride launched January 1, 2008 FlexRide rebranding February 2019	Zone-based Anchor points (stops/stations) 20% of RTD total transit services Curb-to-Curb	15 to 30-minute frequency Reservation or street hailing for timed stops & stations – varies on area $3.00 local $1.50 for 65+ and disabled $0.90 youth	Option of recurring scheduled trips which are good for 180 days and can be renewed 30 days prior. Experienced staff is necessary with market & flex service knowledge. Trips can be scheduled from 10 minutes to 30 days in advance.
	Route 61AV	January 29, 2019 through August 2, 2019	Route-based Autonomous Vehicle	15-minute frequency 4 stops; 10-12 mph; 1-mile route Partnership	Future plans for long-distance routes underway Technology capabilities and shortfalls
Houston METRO	Community Connectors	Pilot began March 2015	Zone-based 3 zones with multiple anchors per zone Shared ride	Call or online ride request Street hail or stop hail $1.25 each way $0.75 seniors & students 7-days a week	Offer pilot demonstration Discontinue redundant fixed-route services
Las Vegas RTC	Trip to the Strip	June 2019	Zone-based (general direction, North or South) Shared ride	Pilot Partnership with Via Up to 11 passengers 24 hours a day Application payment only No surge pricing	Costs less than Uber Pool or Lyft Line Trip starts at $6.00 with no surge pricing Pick-ups and drop-offs are near RTC fixed- route stops or paratransit stops, most located near property entrances
	Navya AV	November 2017 to October 2018	Route-based Autonomous Vehicle	Partnership 0.6-mile route Four right turns and three stops	Manual override will always be made accessible.

Transit Agency	Name	Start Year	Service Type	Frequency and Strategy	Lessons Learned
Salt Lake City UTA	UTA On-Demand by Via	November 2019 Recently approved for continuation through November 2020	Zone-based Corner-to-corner (may not be door-to-door but pick-up and drop-off will be in walking distance) Shared ride	Average wait time is 8.8 minutes, under the goal of 15 minutes. Pilot partnership with Via 65 square miles Transit stations have designated signs for pick-up and drop-offs Via application payment or UTA Pass/Ticket/Transfer in application ADA accessible with confirmation provided through the application.	$1.00 fare through December 31, 2019, with a price increase to $2.50 for adults from January 2020. New program but has reached 216 riders a day in the first 20 days of the program. Goal of 350-450 riders a day within 6 months.
Austin CapMetro	Pickup	June 6, 2017	Zone-based (general direction) $1.25 fare or integrated with other transit service passes Weekdays and 2 services on Saturdays ADA compatible	15- minute headway to pick-up Real-time tracking in application	6 operating zones 1 service route is a permanent replacement for a fixed route Others are subject to change or evolve with rider feedback Service has grown with ridership demand

4. REGIONAL CIRCULATOR CASE STUDIES

Circulator case studies are provided through peer city examples for regional context. The case studies are summarized as a high-level overview of circulator services in the Phoenix metropolitan area. The five local case studies cover exploratory research into the theory and practice of neighborhood circulator services. **Table 10** lists key points of relevant information illustrating unique and common factors of the route-based service type. Incorporated into the studies are the year of implementation, ridership numbers, fares, operations, and lessons learned to inform future programs. Additionally, problems solved, and achievements realized by neighboring cities can guide discussion and action in Phoenix.

Table 10: Peer City Circulator Summary

	Glendale	Tempe	Scottsdale	Mesa	Avondale
					
Name	Glendale Urban Shuttle (GUS)	Orbit/Flash	Scottsdale Downtown Trolley	Mesa Downtown Buzz	Avondale ZOOM
Year of Implementation	1998	Flash began in 2000 Orbit routes added in 2008	1980	2009	July 2011
Funding	Funded through GO! Previously funded by GUS	Transit tax passed in 1996, which originally IDed 8 routes for a "system of neighborhood circulators"	Bed tax and $200,000 contribution from Tourism Board Hospitality Trolley canceled to direct funds towards Downtown Trolley	Streamlined fixed routes removing deviations through downtown Circulator developed to replace deviations Cost savings funded Buzz	Local and Federal Transportation funds
Operational Characteristics	2-way circulator Ridership: 60/70K Primarily serving low-income & primary education students Connects to Valley Metro, low transfers Destinations include DES, library, social services, and Wal-Mart	2-way circulator 6 Orbit routes / 1 Flash route 7-8 buses per route 40-minute loop Connects to transit center, some fixed routes, Scottsdale Trolley, light rail	Additional bus added during spring training 3 routes High number of tourists Connects to Tempe Orbit	2-way circulator 2 buses 6-7 miles Ridership is low-income, high school students, and seniors Small overlap with fixed route	2- way circulator 17 miles Ridership: 190K Connects to Greyhound station Destinations include High Schools, Avondale Civic Center and Library, Wal-Mart, Tolleson City Hall, West Valley Hospital and shopping centers

	Glendale	Tempe	Scottsdale	Mesa	Avondale
Frequency	30 minutes	15 minutes weekdays 30 minutes Sunday	15-20 minutes (Three routes)	60 minutes	30 minutes weekdays
Service Modifications	GUS 3 recently added 10-mile QoL service for Seniors. Can replace dial-a-ride and accesses senior center.	Route tweaks per stakeholder and community input	Re-routed per business owners Conducted survey for Fashion Square inclusion. IDed as major destination and connection hub	Expanding evening service based on survey input (weekday service extension over Sunday service)	October 2019 ZOOM North and South were combined into one bidirectional route
Fare	Was $0.25; now free Low fare did not discourage homeless population and only $21K farebox recovery	Free Low fare to discourage homeless has been discussed but tax language indicates free service	Free	Free	$0.50
Stops	On arterials – Valley Metro stops Non-arterials – can stop in the street Does permit flag stops	Mix of flag stops and signed stops depending on area Designated stops on arterials	Designated stops	Arterial – Valley Metro stops No stops close to homes	Arterial – Valley Metro stops
Operations/Cost	City operated Drivers are city staff 5-6 buses in fleet when service started $600K-$700K to run $9/mile	Initially city operated - Valley Metro currently operates Tempe owns vehicles – Valley Metro operates and maintains $8 million a year	RTW operated $2.2 million for all circulators City maintains ($1.3 million for all costs, including staff and admin) Contract is $32/hour (not per mile)	Valley Metro operated $5.85/mile for 2018	Valley Metro operated $870K for July 2017-July 2018
Vehicles	22’ (12 passengers) 24’’ (29 passengers) Diesel ADA lift (not low floor)	Currently fleet is ½ smaller and ½ larger buses varying on arterial or collector street travel. Smaller are at capacity. Desire for CNG ‘cleaner’ buses	34 Passenger Rubber tire Trolley $500K per vehicle Downtown Trolley will be transitioning to smaller buses.	Valley Metro Used old dial-a-ride vehicles and re-branded VM procured new vehicles	Valley Metro VM trending towards consistent circulator vehicle for all cities, for ease of maintenance

	Glendale	Tempe	Scottsdale	Mesa	Avondale
Lessons Learned	Look at community context and target ridership, ID corresponding destinations: essential vs. choice riders • i.e. seniors, dial-a-ride data, under 18, essential vs. choice riders. Have defined purpose (low-income, senior, tourists, & students) at onset of service. Business and tourist focus only works with high frequency to meet needs of choice riders. Talk to businesses and leaders • i.e. who would want services? HOA, Assisted Living Facilities. Elected official support is key. Safety and Security: drivers have engaged dialogue and eye contact with riders (i.e. where is your destination?) helps deter homeless riding for extended periods. Training and education are key (Focus on elderly and youth) Route will be changed/tweaked over time. • Revise based on community input • Every revision should reference VM Bus Book Costs are higher when city run but easier to make changes.	Dedicated funding source. Establish service with the community vision for system – yields legitimacy. In long-term vision establish service areas but define routes in detail with the community as they come online. Patience, from vision to full-service development takes many years. Route changes with community input for need. Smaller buses are not durable for all day/ everyday service Ridership drops after 6PM.	Valley Metro's on-board survey in 2010, Camelback Study in 2014 used home locations of boarding's and mapped densities. New Service in 2018 based on public input – seniors and shopping. Downtown Merchants Association is helpful information source.	Pilot Circulator, 2013, in SE Mesa (signal Butte): • Charged fare • Good ridership, primarily local residents (not snowbirds) • Key destinations shopping, swap meet • Issues with ADA access, county islands and sidewalk gaps which dictated routing Be aware of ADA access and sidewalk gaps, especially with county islands. Recommend not overlapping with fixed-route service. Once successful, elected officials will want to modify route and expand service. May have Title VI issues with any changes to service. If contracting with Valley Metro, there is need to ensure vehicle type is appropriate. Flag stops in Downtown are not recommended.	The merging of two separate routes with increased frequency has provided connectivity extension. Bi-directional in legible "clockwise" and "counter-clockwise" directions have been noted in a survey as easy to understand. High ridership numbers to reach a myriad of community and business activity centers.