The Optimization of Publicly Regulated E-Hailing Micro-Flex Bus in Low-Density Communities: Implications from four Transit Agencies

**Key words:** Micro-Flex Bus, First Mile-Last Mile

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**Abstract**

Smartphone technology (tech) is re-engineering how people access the shared-use mobility economy. During the past decade, e-hailing services, i.e. ridesharing (Uber, Lyft, Via), ride-splitting (Uber Pool, Uber Express POOL, LyftLine), and microtransit (Bridj, Chariot, Lyft Shuttle, Uber Smart Routes) have inundated U.S. cities, contributing to the menu of mobility choices available to urbanities. The tech-enabled companies are privately funded, are subjected to comply with fewer Federal regulations than public transit operators, permitting more flexibility with service provision and access. There is a growing discourse as to whether the e-hailing services are complementing or competing with public transit. At the same time, transit agencies are challenged with declining ridership and revenues, increasing cost, compounded with protected populations migrating to low-density areas on the fringe of catchment areas. As one response, during the past two years, transit operators started experimenting with e-hailing micro-flexible bus (MFB). This paper explores the convergence of MFB and on-demand technology, employing a case study approach to better understand the service provision, public-private partnerships, and Federal equity compliance of four publicly operated e-hailing MFB programs – FLEX by VTA, Santa Clara, CA; Flex by AC Transit, Newark and Castro Valley, CA; HyperLINK by HART, Tampa, FL; and Pickup by CapMetro, Austin, TX. Using a microtransit on-demand (MOD) matrix, this study compared the programs, finding that service was designed as a FM-LM solution to/from transit facilities, bus routes, and major trip generators within a small relative spatial position (RSP). Additionally, each program was dependent upon some sort of public-private partnership to develop and implement the service. Lastly, all four programs were developed to ensure persons with no smartphone, unbanked customers, and ADA eligible passengers were able to access the service.

**1 Introduction**

The capability to use a smartphone application (app) to plan, request, track, and pay for curb-to-curb shared-use mobility services is transforming urbanities travel choices (Feigon & Murphy 2016, 2018; Clewlow & Mishra 2017; Stiglic et. al. 2018; Westervelt et. al. 2018). In 2009, Uber became the first ridesourcing company to supply on-demand ridesharing/ride(e)-hailing services via a global positioning system (GPS) equipped smartphone. Uber’s business model galvanized an enterprise of peer-to-peer on-demand e-hailing firms, i.e. Lyft, Sidecar, and Via, to name a few (many start-up tech-enabled companies have either merged or collapsed). Based on the e-hailing appeal, in 2014, Uber and Lyft launched UberPool and LyftLine, respectively, introducing ridesplitting into the shared-use arena. Building upon the e-ridesourcing model, ride-splitting pairs customers with analogous trip origins/destinations in real-time, offering passengers a ride for the
up-to half the cost of Uber and Lyft. The following year, the California Public Utilities Commission (CPUC) first defined e-ridesharing firms as Transportation Network Companies (TNC)\(^1\) - “a company that provides transportation services using an online-enabled platform to connect passengers with drivers using their personal vehicles” (CPUC, 2015).

While e-hailing companies were originally used to cannibalize the demand for taxis and rental cars, during the past four years, TNCs have materialized into a first mile-last mile (FM-LM) mobility solution between transit customer's trip origin/destination (Murray et. al. 2016; Stiglic et. al. 2018). Capitalizing on the novice service delivery model, transit operators started cultivating partnerships with TNCs, and subsidizing passengers Uber and Lyft trips within parameters. For example, in 2016, Pinellas Suncoast Transit Agency (PSTA) and Uber developed the nation's first transit agency-TNC partnership. To address the FM-LM conundrum in low-density service areas, the PSTA pays the first $5 of customer's Uber trip to-from bus stops within eight designated zones (PSTA, 2016). Last year, the town of Innisfil, Ontario developed a similarly partnership with Uber, and started subsidizing residents UberPool trips to-from designated public hubs within the township's limits. The town estimates the partnership will save more than $8 million per year on the operating budget compared to equivalent curb-to-curb bus service (BNN 2018). In addition to these two examples, transit providers across the nation are cultivating comparable partnerships with TNCs to deliver alternative services with the goal of increasing access and connectivity.

Influenced by the e-rideshourcing model, and recognizing a transit provision gap, TNCs introduced microtransit into the sharing e-commerce. Microtransit combines elements of public transit's flexible bus service with the e-hailing model, using algorithms to crowdsource customers along dynamic fixed-routes and schedules, offering the capability to shift to flex and on-demand scheduling (Feigon & Murphy 2016). In 2014, Bridj became the first U.S. microtransit company, commencing operations in Boston, MA and Washington, DC, before collapsing at the end of 2016.\(^2\) Chariot also launched in 2014, first beta-testing microtransit in San Francisco, CA and has since expanded operations to Seattle, WA; Austin, TX; San Antonio, TX; New York, NY; and Columbus, OH. Enhancing their customer range, Uber and Lyft started experimenting with microtransit services. In 2015, Uber launched Smart Routes in San Francisco, and last year Lyft launched Lyft Shuttle in San Francisco, CA and Chicago, IL. This year, Uber introduced Express POOL, which almost entirely emulates the public transit model. Express POOL service combines the ridesourcing and crowdsourcing e-hailing model, offering up to 25-percent lower cost rides than UberPool for customers willingly to walk a few blocks to-from the vehicle.

Although e-hailing transport is in an infancy stage, there is a growing discourse as to whether private e-hailing mobility services are complementing or competing with public transit. Recent studies examining the relationship between app-based shared services and the urban space, find that on-demand e-hailing services complement transit networks, in particular, serving as a FM-LM mobility solution (Feigon & Murphy 2016; Stiglic 2018). Other studies find app-enabled ridesharing services are directly competing with transit, and attracting customers away towards curbside e-

\(^1\) TNCs are also known as Mobility Service Provider (MSP).

\(^2\) In December 2017, Bridj started a pilot in Sydney, Australia.
hailing transport (Polzin 2016; Shaheen et al. 2016b; Feigon et al. 2018; Feigon & Murphy 2018). Last year, a U.C. Davis report examined the impact of ride-hailing services, finding that 21-percent of adults living in major U.S. cities use e-hailing services as a frequent mobility mode (Clewlow and Mishra 2017).

Today, there is a menu of e-hailing shard-used services available to urbanities. The competition is further contributing to transit’s declining ridership, causing a domino effect for operators. The reduction in riders is resulting in lower fare revenues collected, which translates to fewer funds available to finance capital and operating budgets. As a result, agencies are prioritizing service provision and reducing service levels, particularly in low-density neighborhoods. Compounding the problem, inner city gentrification is causing the displacement of socioeconomic disadvantaged populations (SED) to the suburbs, in which research is starting to show that transit deserts are emerging in outlying communities (Jiao & Dillivan 2013; Allen 2014; LaBelle & Freve 2016; Jiao 2017). While transit operators are facing unsustainable budgets, the Federal Transit Administration (FTA) mandates financial recipients to ensure equitable distribution of transit benefits for minority, low-income, and disabled populations.

In response to the e-hailing services and strained budgets, public entities are adapting their service delivery models. In a recent attempt to compete with the private industry, public entities started partnering with tech-enabled mobility companies and contracting out microtransit services. The cities of West Sacramento, CA and Arlington, TX became the first two municipalities to supply publicly regulated microtransit bus service. Comparably, a few transit agencies started experimenting with publicly operated micro-flex bus (MFB) service, allowing passengers to use a smartphone app to hail a vehicle. The operators are testing e-hailing MFB service to determine if it can serve as a low-cost and FM-LM solution to fixed-route bus (FRB) service in low-density areas. A recently published Eno Center for Transportation report examined three e-hailing MFB projects, arguing there is an opportunity for transit operators to leverage technology to increase transit ridership (Westervelt, et al., 2018).

As transit operators are starting to integrate e-hailing MFB service into operational practice, there is plenteous opportunity to identify best practices. This paper explores the convergence of public transit, in particular MFB and on-demand technology. This research employs a case study approach to better understand the service provision, approach to public-private partnerships, and Federal horizontal/vertical equity compliance of four e-hailing MFB projects – FLEX by Valley Transportation Authority, Santa Clara, CA; Flex by Alameda-Contra Costa Transit District, Newark and Castro Valley, CA; HyperLINK by Hillsbourough Transit Authority, Tampa, FL; and Pickup by CapMetro, Austin, TX. These projects were selected because were among the first cohort in the U.S. to test e-hailing public transit in low-density areas. For this paper I developed a microtransit on-demand (MOD) matrix that answered the following questions:

1. What were the service and operating characteristics of the e-hailing MFB service?
2. How did the transit operator leverage private-partnerships to supply the e-hailing MFB service?
3. How did the e-hailing MFB service comply with Title VI of the Civil Rights Act of 1964, Executive Order 12898 (1994), and the American with Disabilities Act of 1990?

To populate the MOD matrix, data was used from National Transit Database (NTD), the transit provider’s website, and the Internet. In the MOD matrix, the data was compared and analyzed for discussion. As more public entities integrate app-enabled on-demand transit into their operational practices, this paper will provide transit operators, policy makers, researchers, and equity advocates with preliminary best practices for e-hailing MFB service.

1.1 Defining App-Enabled Micro-Flex Bus

Public transit is the original and longest-standing shared-used mobility mode, withstanding automobile competition, decentralization and suburbanization, unsustainable budgets, and indirect multimodal connectivity. As one response to the adverse impacts, beginning in the 1960s, transit agencies across the U.S. replaced conventional FRB operations with demand responsive bus (DRB) service (Koffman 2004). Following the Americans with Disabilities Act of 1990, public agencies started employing dial-a-ride (DAR)/paratransit bus service to comply with the Federal legislation (Weiner 2008). During the most recent two decades, public entities have supplied hybrid FRB and DRB/DAR bus service to increase access and connectivity in low-demand areas, which has become known as flexible transit (or MFB). MFB is a small vehicle (usually a cut-away) that operates within a relative spatial position (RSP), generally less than seven miles, and offers passenger deviations per request (Potts et. al. 2010). In TCRP Synthesis 53, Koffman (2004) first identified and defined the six common types of MFB services operated by transit agencies (see Table 1). In the follow-up TCRP Report 140, Potts et. al. (2010) found from a survey of 1,100 transit operators, the 39-percent of the 500 respondents supplied one or more types of MFB service.²

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route Deviation</td>
<td>Vehicles operate on a regular schedule along a defined path, with or without marked bus stops, deviating to serve demand responsive requests.</td>
</tr>
<tr>
<td>Point Deviation</td>
<td>Vehicles serving demand responsive requests within a zone and also serving a limited number of stops within the zone without any regular path between the stops.</td>
</tr>
<tr>
<td>Demand Responsive Connector</td>
<td>Vehicles operating in demand responsive mode within a zone, with one or more scheduled transfer points that connect with a fixed-route network.</td>
</tr>
<tr>
<td>Request Stops</td>
<td>Vehicles operating in fixed-route, fixed-schedule mode and also serving a limited number of undefined stops along the route in response to passenger requests.</td>
</tr>
<tr>
<td>Flexible Route Segments</td>
<td>Vehicles operating in conventional fixed-route, fixed-schedule mode, but switching to demand-responsive operation for a limited portion of the route.</td>
</tr>
<tr>
<td>Zone Route</td>
<td>Vehicles operating in demand responsive mode along a corridor with established departure and arrival times at one or more end points in the zone.</td>
</tr>
</tbody>
</table>

Source: TCRP Synthesis 53: Operational Experiences with Flexible Transit Services, 2004

Beginning in the late-2000s, start-up tech-enabled firms started the shift towards app-enabled e-hailing shared-use services. A decade later, popular e-hailing services Uber, Uber Pool, Uber Express POOL, Lyft, LyftLine, Via, Bridj, and Chariot have inundated U.S. cities, contributing to the plethora of mobility choices available to urbanites. To remain competitive, transit operators are

² There is currently a study underway by TCRP to determine innovative demand response bus service delivery models.
adapting their MFB to include an e-hailing component. Influenced by the e-ridesourcing model, agencies are starting to operate MFB bus service that allows passengers to use a smartphone to request the bus in real-time. This is newest service delivery model in the transit arena, which is designed to compete with private tech-enabled companies. The principal goal of the bus is to connect passengers in low-density areas to high frequency FRB routes, rail stations, or specific point of interest with a designated geographic zone.

1.2 Report Organization
This introductory section set the stage for the study. The remainder of this report is structure as follows:

- **Section 2**, synthesizes previous research associated with MFB, with a focus on operations in low-density communities, followed by how on-demand technology is reshaping how people access transport.
- **Section 3**, describes the methodology for undertaking the case studies.
- **Section 4**, presents the case studies.
- **Section 5**, discusses and compares the results of the MOD matrix.
- **Section 6**, summarizes the results, identifies future research, and present policy implications.

2 Review of Relevant Research
Before examining the four-transit operator’s e-hailing MFB programs, a review of relevant intricacies is deemed necessary. Voluminous research documents public entities experience with hybrid FRB and DRB, finding that a significant number of U.S. transit operators integrated the use the service delivery mode in low-density environments (Daganzo 1977, 1978, 1984; Fu 2002; Horn 2002). The Transportation Cooperative Research Program (TCRP) has supplemented the research and published three best practice reports that surveyed transit agencies experiences with MFB. In TCRP Synthesis 53: *Operational Experiences with Flexible Transit Services*, Koffman (2004) found that during the 1980s and 1990s, agencies started replacing FRB with DRB in low demand areas. Complementing TCRP Synthesis 53, in TCRP Synthesis 76: *Integration of Paratransit and Fixed-Route Transit Services*, Weiner (2008) added that during the 2000s agencies started using MFB as feeder service to bus routes, transit facilities, and trip generators in outlying areas. In the follow-up TCRP Synthesis 140: *A Guide for Planning and Operating Flexible Public Transportation Services*, Potts et. al. (2010) confirmed previous practices, contributing that MFB service will require technology that exceeds FRB to attract new riders.

2.1 Operating Micro-Flex Bus Service in Low-Density Landscapes
In more recent years, the optimization of MFB in low-density areas has attracted considerable interest from researchers. Research continues to confirm that the substitution of FRB service with MFB services is more cost-efficient to serve low-density areas (Alshalafah & Shalaby 2011; Kim & Schonfeld 2013, 2014; Qiu & Haghani 2015). A significant number of recent studies recommend MFB as a feeder (FM-LM) service to transit stations and high frequency bus routes (Li & Quadrifoglio 2010; Alshalafah & Shalaby 2012; Allen 2014; Fittante & Lubin 2015; Qui et. al. 2015). For example, Chen & Nie (2017) developed a demand adaptive paired-line hybrid transit (DAPL-HT) that connects passengers to fixed-route services to improve access.
Complementary research is starting to provide evidence that transit deserts are emerging in suburban communities, outside agencies catchment areas (Jiao & Dillivan 2013; Jiao 2017; Allen 2018). In Operating within Transit Deserts: The Application of Just, Open and Equitable Circulator Systems within Outer Urban Residential Neighborhoods, Allen (2014) proposed the use of neighborhood circulators to improve equitable access in suburban communities. The researcher argued, “circulators provide a secondary or localized service that connects passengers to suburban transit hubs, in addition to servicing as a complementary mode to the transit network.” A report published by the Urban Transportation Center at the University of Illinois, Chicago recommended the integration of MFB service in suburban low-density areas have the potential increase mobility and access for transit dependent populations (LaBelle & Freve, 2016).

### 2.2 On-Demand, E-Hailing Transport

While app-enabled shared-used services are in an infancy stage, there is a limited, but mounting body of literature exploring how on-demand technology is reshaping how people access transportation. Advancements in smartphone technology, in particular the iPhone and Android equipped with GPS and banking capabilities pioneered the shift towards the e-hailing economy. In Smartphone Applications to Influence Travel Choices: Practices and Policies, Shaheen et. al. (2016) argued that the plethora of mobility apps have the potential to enhance urban mobility. In Implications to Public Transportation of Emerging Technologies, Polzin (2016) asserted that with the aggressive emergence of competitive app-based mobility providers, transit agencies must adapt to the changing nature with innovative service delivery models. An Eno Center for Transportation (2016) study recommended subsidizing transit projects that use innovative technologies, i.e. app-enabled for the service delivery model.

Complementing previous research, recent studies argue that e-hailing mobility services are prime candidates for FM-LM solutions outside of the transit agencies shed, in particular spatially fragmented zones (Feigon & Murphy 2016; Shaheen & Chan 2016). In a recently published report, Stiglic et. al. (2018) argued that with the proliferation of tech-enabled transport, there is an opportunity for transit providers to capitalize on the innovations and supply e-hailing service as a FM-LM.

As e-hailing shared-use services become common practice, there are a substantial number of recent studies that emphasize the importance of encouraging horizontal and vertical equity. In an Institute for Transportation & Development Policy report, Kodransky & Lewenstein (2014) argued that while there is no exact mechanism to improve transit access for socioeconomic disadvantaged populations (SED), e-hailing MFB service is one of several mobility modes that are most practical for this socioeconomic group. The researchers found that innovations ride-sharing – reoccurring, medium to long distance trips (5-20 miles) are best suited for employment, educational, healthcare, groceries, and childcare trips. In regards to equity, the researchers provide two recommendations: (1) pilot projects based on research that identifies transportation lessons learned from SED communities, and (2) research shared mobility business models, in particular with cross-sector partnerships, with a goal of better understanding how to increase access to SED communities.
The Eno Center for Transportation (2016) report also suggest setting appropriate standards to assist SED populations in gaining access to the benefits provided by technology. In TRB Special Report 319, Kortum (2016) examined the rise of technology-enabled transport services, finding that innovative mobility services are expanding transportation choices, and there is the potential to increase access for SED persons. Shaheen et. al. (2016b) identified guiding principles for public entities when integrating app-based mobility in their operations – ensure social, interregional, and intergenerational equity to meet the basic transportation needs of SED populations. Feigon & Murphy (2016) examined the relationship between public transit and shared-use modes, arguing that as agencies move towards app-based payment ensure Title VI compliant – address unbanked customers purchase fares using cash or with no bank account/credit card. In a follow-up study, Feigon and Murphy (2018) found that TNC usage takes place in communities across all socioeconomic groups, arguing there is a need to ensure low cost e-hailing transportation for SED populations. Westervelt et. al. (2017) recommended that as transit agencies develop pilot e-hailing services, Title VI accessibility compliance should be a high priority.

In addition to addressing equity, a few recent reports encouraged cross-sector partnerships to deliver publicly regulated e-hailing shared-use services (Feigon & Murphy 2016; The Eno Center for Transportation 2016; Westervelt et. al. 2017). In the recently published TCRP Report 196: Private Transit: Existing Services and Emerging Directions, Feigon et. al. (2018) recommended the use of consortium-based services in suburban or low-density areas that use app-based services to connect workers to high-capacity transit.

3 Methodology
As the shared-used economy is shifting from dial-a-ride MFB towards e-hailing MFB, there is ample opportunity to identify best practices. This paper explores the convergence of public transit, in particular MFB and on-demand technology, and is guided by the following research questions:

1. **Service provision.** What were the service and operating characteristics of the e-hailing MFB service?
2. **Public-private partnerships.** How did the transit operator leverage consortiums to supply the e-hailing MFB service?
3. **Horizontal/vertical equity.** How did the e-hailing MFB service comply with Title VI of the Civil Rights Act of 1964, Executive Order 12898 (1994), and the American with Disabilities Act of 1990?

3.1 Data Sources
Data to complete the case study data was compiled from the following sources:

1. **National Transit Database.** The 2016 Annual Agency Profile for each transit operator was used, extracting – service area characteristics (square miles and population); identification of modes operated; operational characteristics (unlinked trips, operating expenses, fare revenues); and service effectiveness (operating cost per trip). The farebox recovery ratio was calculated for DRB using the following formula: fare revenues/operating expenses.
2. **Agency website.** The perspective agencies website was used to gather and learn about the MFB program, including the service and operating characteristics, approaches to public-private partnerships, and addressing Federal equity compliance. First, archived Board of Directors meeting minutes were reviewed to understand the historical context of the program and approved critical decisions about the project. Additionally, the agencies project details on the website were reviewed to further learn about the MFB program.

3. **Internet.** Lastly, online research consisting of press releases and media articles associated with the project was reviewed.

### 3.2 Case Selection

The following two factors influenced my decision to use the agencies in this case study:

1. The transit agencies among the first in the U.S. to experiment with e-hailing MFB service.
2. The transit operator introduced the e-hailing MFB service in low-density spatially fragmented areas.

### 3.3 Case Cities

The pilot programs and agencies are:

- **FLEX** by Valley Transportation Authority, Santa Clara, CA
- **Flex** by Alameda-Contra Costa Transit District, Newark and Castro Valley, CA
- **HyperLINK** by Hillsbourough Transit Authority, Tampa, FL
- Pickup by CapMetro, Austin, TX

### 3.4 Descriptive Analysis

To understand the context of the cities and pilot programs, a descriptive analysis was conducted using data collected from the NTD.

### 3.5 Microtransit On-Demand (MOD) Matrix

Following the descriptive analysis, data collected from the agency website and Internet research were populated into microtransit on-demand (MOD) matrix. The variables were compared for discussion.

### 4 Case Studies

#### 4.1 **FLEX by Santa Clara Valley Transportation Authority, CA**

The Santa Clara Valley Transportation Authority (VTA) operates light rail, FRB (local and express), and DRB services in San Jose, CA, and surrounding low-density bedroom communities, providing service to approximately 2 million people within a 350-mile square radius. According to the NTD Annual Agency Profile (2016), DRB trips account for 1.5% of the systemwide ridership and 6.4% of the overall operating expenses. The operating cost per trip is $27 more than FRB and LRT. Additionally, DRB service farebox recovery ratio is 12%, about five 5% more than the national average (FTA, 2017).

*Figure 1: FLEX Service Area*
In January 2016, the VTA launched a six-month on-demand, e-hailing MFB pilot program. The purpose of the program, FLEX was three-fold: (1) increase ridership, (2) improve farebox recovery rates; and (3) use technology to deliver dynamic transit provision (Miskell, 2016). As shown in Figure 1, Santa Clara was selected as the pilot area for its low-density residential uses, compounded with employment destinations and connections to LRT service. The MOD matrix describes and compares the service provision, approach to P3, and Federal equity compliance of the FLEX program.

4.2 **Flex by Alameda-Contra Costa Transit District, CA**

The Alameda-Contra Costa Transit District (AC Transit) is the third largest public transit system in California. Located in the East Bay, AC Transit supplies FRB (local and express), CB, and DRB bus service to 13 cities and adjacent unincorporated areas in Alameda and Contra Costa counties. The bus-only agency provides service to 1.5 million people spanning 364 square miles. AC Transit operates in both dense and low-density communities, connecting passengers with numerous transit facilities, major shopping centers, and point of interest. According to the NTD Annual Agency Profile (2016), DRB trips account for less than 2% of the systemwide ridership, and 9.0% of the operating expenses. The operating cost per trip is $43 more than FRB and CRB service. Additionally, DRB service farebox recovery ratio is 7%, which is on par with the national average (FTA, 2017).

Since the mid-2000s, the agency has deliberated with how to supply alternative service delivery models in low-demand areas. In 2013, the AC Transit Mobility Management Task Force was formed, and the following year, recommended a one-year pilot program, allowing passengers to use a smartphone to request the bus (AC Transit, 2014). The goals of the program were to: (1) test an innovative service delivery model aimed at improving service in low-density of the District; (2) respond to changing customers expectations regarding on-demand transport fueled by the popularity of Uber and Lyft. In July 2016, AC Transit commenced the beta testing of a dynamically demand response service called Flex in two service areas (see Figure 2), temporarily suspending Route 275 (the route has since be replaced with Flex). The MOD matrix describes and compares the service provision, approach to P3, and Federal equity compliance of the FLEX program.
4.3 HyperLINK by Hillsborough Area Regional Transit Authority, FL
The Hillsborough Area Regional Transit Authority (HART) provides FRB (local and express), DRB including paratransit and general public, BRT, and Streetcar throughout Hillsborough County, Florida. The service area spans 255 square miles, providing service to more than 875,000 people. According to the NTD Annual Agency Profile (2016), DRB trips account for 1% of the systemwide ridership, and about 8% of the operating expenses. The operating cost per trip is $31 more than the other service modes. The DRB service farebox recovery ratio is 11%, which is 4% above the national average (FTA, 2017).

Transit operators in Florida are pioneers in MFB operations. According to a USF, Center for Urban Transportation Research (2013) report, six public entities supply some type of on-demand MFB within the state. HART is one of the six that operates a well-established MFB network. In 2010, the agency introduced the first two HARTFlex routes in Brandon and South County. The following year, based on the program’s success, three additional HARTFlex routes were added in Northdale, South Tampa, and Town ‘N County. In November 2016, introduced HyperLINK, extending the footprint of HARTFlex in two areas (Figure 3), allowing passengers to use a smartphone to hail an on-demand vehicle. The MOD matrix describes and compares the service provision, approach to P3, and Federal equity compliance of the HyperLINK program.

Figure 3. HART HyperLINK University, Temple Terrace, and Brandon Service Areas


4.4 *Pickup by Capital Metropolitan Transportation Authority, TX*

The Capital Metropolitan Transit Authority (CapMetro) operates a combination of FRB (local and express), CB, demand response taxi, vanpool, hybrid commuter rail, and DRB service to an area spanning more than 500 square miles and serving about 1.1 million people. Austin is the centroid of the services, in which areas outside the central business district is a sprawling region comprised of low-density spatially fragmented uses. According to the NTD Annual Agency Profile (2016), DRB trips account for about 2% of the systemwide ridership and 18% of the operating expenses (the highest among the case studied cities). The operating cost per trip is nearly $54 more than the system total. Additionally, DRB service farebox recovery ratio is 2%, about 5 percentage points lower than the national average (FTA, 2017).

**Figure 4. CapMetro PickUp Service Area**

In June 2017, CapMetro launched PickUp, an e-hailing bus service that allows customers to use a smartphone app to request the vehicle to their curb. The purpose of the yearlong pilot is to assess the feasibility of publicly operated app-enabled transit in low-density neighborhoods. For that reason, a suburban northeast suburban neighborhood was selected for the pilot. Figure 4 displays the PickUp service zone. The MOD matrix describes and compares the service provision, approach to P3, and Federal equity compliance of the PickUp program.

5 **Public Microtransit On-Demand**

Similar to the ridesourcing and microtransit business models, each transit agency supplied curb-to-curb on-demand service via a smartphone app. The app allowed passengers to request, pay, and track their vehicles. In addition, customers received a notification on their smartphone when the vehicle is approaching. This section discusses and compares the four agencies e-hailing MFB services, to include the service provision, approaches to public-private partnerships, and Federal equity compliance adherence.

5.1 **Service provision**

- **Coverage area.** The HART HyperLINK program provides service to four areas within Tampa. Each zone spans 3-miles, in which the University and Temple Terrace zones overlap to cover the University of South Florida campus. The Brandon area encompasses two overlapping zones. Collectively, the HyperLINK program serves a 12-mile radius of e-hailing MFB service. Both the VTA’s FLEX and AC Transit’s Flex program supply service within a 6-square mile radius, in which the Flex bus operates in two zones, also supplying 12-miles of service. While CapMetro’s PickUp program only operates in one zone, the coverage area spans a 12 square mile radius.

- **Span.** The VTA FLEX and AC Transit Flex operates on weekdays, offering continuous service from the morning peak period (VTA – 5:30am and AC Transit – 6am) to an hour
after the evening peak period (VTA – 8:30pm and AC Transit – 8pm). CapMetro’s PickUp service operates six days per week, supplying continuous service from the start of the morning peak period until the end of the evening peak period. On the Saturdays, the program offers seven hours of service (10am-5pm). HART’s HyperLINK supplies daily service, spanning from 530am to 1030pm, the most service days and the longest service span of the case studies.

- **Vehicles.** Three of the programs (FLEX, Flex, and PickUp) used existing rolling stock of demand response cutaway vehicles, ranging from 12 to 16 seats. The HyperLINK program uses three types of Telsa vehicles – SUVs, Model X, and MV-1. HART is the first transit agency in nation to partner with Telsa for the use of public service delivery.

- **Designated bus stops.** Within each program’s designated service area there are trip generators to include schools, community centers, social service agencies, shopping plazas, restaurants, medical institutions, and government facilities. In addition to single-family and multi-family residential homes. However, each program operates different types of bus ingress/egress models. For the VTA FLEX program, there are 200-plus bus stops, in which customers are only able to board and alight at the designated stops. Similarly, while AC Transit’s Flex service is on-demand, there are designated stops in which customers are required to identify their boarding and alighting stops at the time of reservation. In addition to the designated stops, the program offers one (1) non-reserved stop – the two BART stations, departing every 30 minutes. There are no designated stops for the CapMetro PickUp service, the buses will pick-up and drop-off customers anywhere requested within the program service area. HART’s HyperLINK program offers customers the option to ride anywhere within the service zones, or between two designated bus stops for a reduced fare.

- **First Mile-Last Mile solution.** A vital component of each program was to address the FM-LM conundrum in low-demand areas. The HyperLINK program provides a substantial number of FM-LM connections to the HART network, connecting to transit centers and numerous local and express FRB routes. In addition, to serving as a FM-LM connection to a major university, hospital, and city hall within the designation zone. AC Transit’s Flex bus serves park & ride lots, one BART station, and one Amtrak station. Similarly, the VTA’s FLEX program serves the light rail system, three lines and nine stations, in addition to one (1) transit center. CapMetro only serves one commuter rail station.

### 5.2 Public-Private Partnerships (P3)

All four programs were dependent upon some sort of P3 to implement and/or operate the e-hailing MFB services.

- **Consortium.** HART’s HyperLINK was made possible by a Florida Senator championing a grant state grant to fund the service. The initial three zones were agency sponsored, in which service delivery was contracted to TransDev. In 2017, the Tampa Innovation Alliance encompasses five public-private entities formed to sponsor the fourth service area to enhance mobility within the University area of North Tampa. At the time this study was undertaken, none of the other agencies developed consortiums to enhance their programs.
• **Funding.** HyperLINK is the only program to a dedicated source of funding. HART applied and received a $1.2 million startup grant from the Florida Department of Transportation to finance the HyperLINK program. Since the programs inception, a Florida Senator has made in additional $500,000 appropriations request in the Florida Senate budget for expansion of the HyperLINK program into downtown Tampa. The remaining programs were funding from the agencies operational budgets. Existing fleet and drivers were used, in which only extra cost were for technology packages and bust stop signage.

• **Technology.** Each transit agency collaborated with a different private technology company to develop a user-friendly smartphone app. The apps were designed to allow for intuitive trip with built in routing algorithms – a map-based trip screen to request a ride; integrated payment system – credit card within the app, or pay cash inside the vehicle; and real-time, vehicles are equipped with real-time location tracking (CAD/AVL systems) to track the bus to passengers curbside.

   The app developing companies are as follows: VTA FLEX contracted with Ridecell; AC Transit Flex contracted with DemandTrans; HART HyperLINK contracted with TransDev; and CapMetro contracted with Via.

5.3 **Addressing Horizontal/Vertical Equity**

The programs considered the various equity components during the development of the program, to include fare and transfer policy, customers that are unbanked and have no access to a smartphone, and ADA passengers.

• **Fare and transfer policy.** All four programs have different fare structures that are deemed equitable compared the remaining system. The PickUp program is free during the pilot phase, hence passengers utilizing the service save money. AC Transit's Flex fare is $2.25, the same as the bus base fare. The VTA and HART programs offer unique fares. VTA's FLEX fares were $3 during the peak period (75-cent more than bus base), and $2 during the off-peak period (25-cent less than the bus base). HART HyperLINK's are $3 anywhere within the program's service area, and passengers are offered a discount fare ($1) for rides that originate and terminate at designated bus stops. Of note, all four programs offer no transfers, requiring passengers to pay a separate fare to ride additional modes.

• **No smartphone access.** While each program allows passengers to use the agency's smartphone app to request, track, and pay for the bus, alternative methods are offered to ensure equitable access. If available, passengers can use the agency's website or a tablet to request a ride. In addition, customer service call centers are available for passengers to request a bus, in which riders are subjected to the same wait time as a person who utilizes a smartphone.

   If using a smartphone, the agencies app is only available on IOS and Android devices. These phones are among the highest priced phones on the market, in which low-income populations may be unable to afford the phone.

• **Unbanked passengers.** Building off the notion that SED populations may not possess a bank account or credit card, each program permit customers to pay cash while boarding.
the bus (CapMetro PickUp is free). In addition, AC Transit's program allows customers to use the agency's smartcard or a daypass to pay for their ride.

- **ADA compliance.** All four agencies operate fully ADA compliant vehicles that are wheelchair accessible. With the exception of the HyperLINK program, existing rolling stock was used to supply the service. Additionally, current ADA paratransit operators were used to drive the vehicles, only requiring training on the new technology. Hence, drivers possess the capability to handle customers in wheelchairs or blind customers.

### Table 2. Micro-Flex On-Demand (MOD) Matrix

<table>
<thead>
<tr>
<th>Variables</th>
<th>FLEX, VTA</th>
<th>Flex, AC Transit</th>
<th>HyperLINK, HART</th>
<th>PickUp, CapMetro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coverage area</td>
<td>1 zone&lt;br&gt;<strong>•</strong> In Santa Clara</td>
<td>2 zones&lt;br&gt;<strong>•</strong> In Union City&lt;br&gt;<strong>•</strong> In Castro Valley</td>
<td>4 zones (Tampa, FL)&lt;br&gt;<strong>•</strong> Brandon (2 zones)&lt;br&gt;<strong>•</strong> Temple Terrace&lt;br&gt;<strong>•</strong> University</td>
<td>1 zone&lt;br&gt;<strong>•</strong> In northeast Austin</td>
</tr>
<tr>
<td>Square miles</td>
<td>6-mile radius</td>
<td>6-mile radius</td>
<td>3-mile radius</td>
<td>12-mile radius</td>
</tr>
<tr>
<td>Days/Hours</td>
<td>Weekdays&lt;br&gt;<strong>•</strong> 530am-830pm</td>
<td>Weekdays&lt;br&gt;<strong>•</strong> 6am-8pm</td>
<td>Daily&lt;br&gt;<strong>•</strong> 530am-1030pm</td>
<td>Weekdays&lt;br&gt;<strong>•</strong> 7am-7pm&lt;br&gt;Saturday&lt;br&gt;<strong>•</strong> 10am-5pm</td>
</tr>
<tr>
<td>Vehicle type</td>
<td>Cutaway</td>
<td>Cutaway</td>
<td><strong>•</strong> Tesla SUV&lt;br&gt;<strong>•</strong> Tesla Model X&lt;br&gt;<strong>•</strong> Tesla MV-1</td>
<td>Cutaway</td>
</tr>
<tr>
<td>Designated bus stops</td>
<td>More than 200&lt;br&gt;<strong>•</strong> Union City&lt;br&gt;<strong>•</strong> Designated – 1&lt;br&gt;<strong>•</strong> Trip generators – 12&lt;br&gt;<strong>•</strong> Castro Valley&lt;br&gt;<strong>•</strong> Designated – 1&lt;br&gt;<strong>•</strong> Trip generators – 9</td>
<td><strong>•</strong> Point of interest – 6</td>
<td>Points of interest - 2</td>
<td></td>
</tr>
<tr>
<td>Service provision</td>
<td>Light rail lines – 3&lt;br&gt;Light rail stations - 9</td>
<td>Union City&lt;br&gt;<strong>•</strong> Park &amp; Ride – 1&lt;br&gt;<strong>•</strong> Amtrak - 1&lt;br&gt;<strong>•</strong> Heavy rail – 1&lt;br&gt;<strong>•</strong> Castro Valley&lt;br&gt;<strong>•</strong> Park &amp; Ride – 2&lt;br&gt;<strong>•</strong> Heavy rail – 1</td>
<td>Brandon&lt;br&gt;<strong>•</strong> Local bus – 6 routes&lt;br&gt;<strong>•</strong> Express bus – 4 routes&lt;br&gt;<strong>•</strong> Transit center – 1&lt;br&gt;University&lt;br&gt;<strong>•</strong> Local bus – routes&lt;br&gt;<strong>•</strong> Express bus – routes&lt;br&gt;<strong>•</strong> Transit center – Temple Terrace&lt;br&gt;<strong>•</strong> Local bus – routes&lt;br&gt;<strong>•</strong> Express bus – routes&lt;br&gt;<strong>•</strong> Transit center – Local bus – 12 routes&lt;br&gt;<strong>•</strong> Express bus – 3 routes&lt;br&gt;<strong>•</strong> Transit center – 1</td>
<td>Light rail station - 1</td>
</tr>
<tr>
<td>FM-LM connections</td>
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<td></td>
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<td></td>
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<td>Public/Private Partnerships</td>
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<td>None</td>
<td>Tampa Innovation Alliance, 5 companies</td>
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<td>Technology</td>
<td>RideCell</td>
<td>DemandTrans</td>
<td>TransDev</td>
<td>Via</td>
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<td>Variables</td>
<td>FLEX, VTA</td>
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<tr>
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<td>------------------</td>
</tr>
<tr>
<td>Service provider</td>
<td>Transit agency (public transit contractor)</td>
<td>Transit agency (public transit contractor)</td>
<td>TransDev (public transit contractor)</td>
<td>Transit agency (public transit contractor)</td>
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<td>Agency operating budget</td>
<td>Florida Department of Transportation • $1.2 million operating grant</td>
<td>Agency operating budget</td>
</tr>
<tr>
<td>Fare</td>
<td>Bus base fare: $2.25 • $3 during peak • $2 during off-peak</td>
<td>Bus base fare: $2.25 • $2.25 for adults $1.10 for youth, disabled, &amp; seniors</td>
<td>Bus base fare: $2.00 • $1 to/from designated stop • $3 to/from anywhere in HyperLINK zone</td>
<td>Bus base fare: $1.25 • Free (during pilot)</td>
</tr>
<tr>
<td>Transfer policy</td>
<td>Separate payment</td>
<td>Separate payment</td>
<td>Separate payment</td>
<td>Separate payment</td>
</tr>
<tr>
<td>Reservations</td>
<td>* FLEX app</td>
<td>* Smartphone Internet</td>
<td>* HyperLINK app</td>
<td>* PickUp app</td>
</tr>
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<td>Smartphone type</td>
<td>* IOS • Android</td>
<td>* IOS • Android</td>
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</tr>
<tr>
<td>Payment</td>
<td>* FLEX app</td>
<td>* Flex app</td>
<td>* HyperLINK app</td>
<td>* Free</td>
</tr>
<tr>
<td>Customers with no smartphone</td>
<td>* VTA call center • VTA website</td>
<td>* AC Transit call center • Desktop &amp; tablet</td>
<td>* HART call center</td>
<td>* CapMetro call center</td>
</tr>
<tr>
<td>Unbanked customers</td>
<td>* Cash onboard bus • Clipper card • Day pass</td>
<td>* Cash onboard bus</td>
<td>* Cash onboard bus</td>
<td>Free</td>
</tr>
<tr>
<td>ADA (Wheelchair accessible)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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</tbody>
</table>

6 Summary, Future Research, and Policy Implications

As shown in this study, four transit agencies have integrated e-hailing MFB service into their operational practices with similar and varying characteristics.

6.1 Summary of Findings

- **Service provision.** Each provider operates similar and varying service and operating characteristics. While AC Transit’s Flex, HART’s HyperLINK, and CapMetro’s PickUp operate a different number of zones, each program’s total service coverage area spans 12-square miles.

- **Public-private partnerships.** Each program was dependent upon partnerships to operate the service. As a common practice with DRB/paratransit, the service was contracted to a known transit provider. The transit operators relied on technology firms to build their smartphone apps. Lastly, HART was able to capitalize on Florida’s grant program, and fund the start-up cost for the program.

- **Horizontal/Vertical equity.** All four programs were deemed Title VI, Environmental Justice, and ADA compliant. The agencies took measures to ensure persons with no smartphone access were able to access the service (call centers were made available). In addition, for the

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<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
unbanked passengers, all allowed passengers to pay cash onboard vehicles (PickUp is free). Lastly, each program supplied ADA wheelchair accessible vehicles.

6.2 Future research
With the e-hailing MFB service in infancy stage, there is an abundance of opportunity for future research.

- **Utilization.** More research is needed to assess ridership levels. While ridership statistics were readily available for the AC Transit Flex and HART HyperLINK, with the infancy of the programs utilization was excluded from the study.

- **Impacts.** One purpose of each program was to reduce DRB operating cost and operating per trip, and improve the farebox recovery ratio. Future research is recommended to assess whether the cost decrease and farebox recovery increase.

- **Funding.** HART HyperLINK is the only program with a dedicated funding source. Additional research is needed to identify the funding opportunities to finance innovative transit projects.

- **Marketing.** While each agency embarked on marketing campaigns to promote the e-hailing bus service, this study did not examine the impacts of the marketing initiatives. Further research should assess how marketing efforts impacted the ridership.

Policy implications

- **Fare and transfer policy.** None of the fare systems are integrated. To ensure customer attractiveness, transit agencies should implement free or reduced fare transfers.

- **Late night service.** Agencies should improve their span of service policy to include late night operational hours to ensure shift workers are able to access to service.

7 References


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