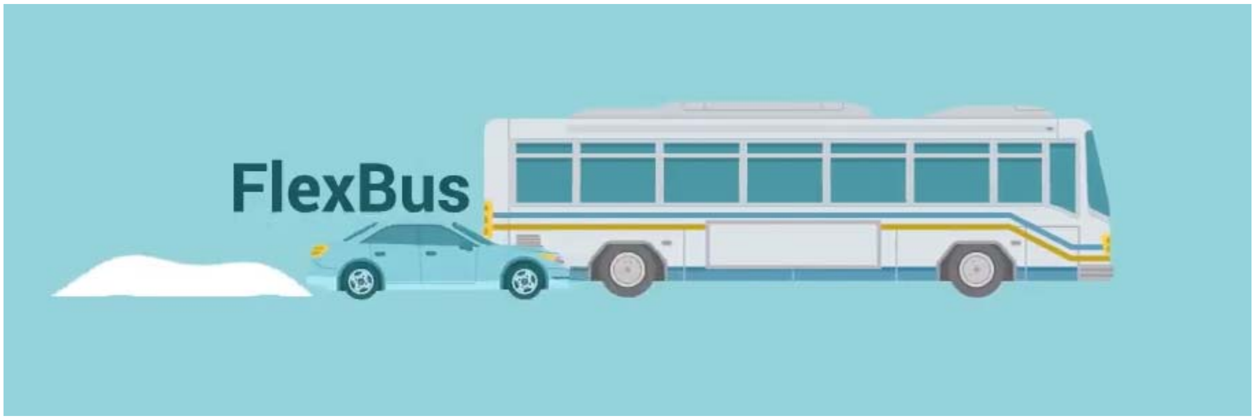
FlexBus: Improving Public Transit with Ride-hailing Technology



Dow Sustainability Fellowship

Omid Bahrami
Jim Gawron
Jack Kramer
Bob Kraynak

December 2017

Executive Summary

In this report, we present to the Ann Arbor Area Transportation Authority (AAATA) the financial, social, and environmental merits of offering subsidized ride-hail services to residents in areas that cannot be efficiently covered by buses. We call this subsidized ride-hail service FlexBus. While the research, design, and analysis of this report was conducted specifically for the AAATA, we hope that the information and insight will be broadly applicable to any transit agency considering on-demand ride-hailing.

We conducted an extensive literature review of the ride-hailing services that have already been integrated into transit systems in pilot projects around the world. By presenting the pros and cons of each ride-hail variant and subsidy design available for such partnerships, we determined that a fixed bus route replacement with geo-fenced point-to-point service was optimal for the AAATA. This replacement should be for the full day and the on-demand service should be subsidized so that riders pay only a single, flat-fare equal to the prevailing bus fare. We also determined the logistics of entering such a partnership with a private ride-hail provider.

Using a team-developed route selection framework, we identified bus route 67 as having ideal characteristics to be replaced with more flexible ride-hail service. The main rationale is that 67 has low ridership levels and little overlap with other bus routes while running through a geographic area that can be covered well by a geo-fenced ride-hail zone. Replacing route 67 with FlexBus service could save the agency up to $84 per hour while providing riders with an on-demand service that picks them up at their doors instead of at bus stops. We also conducted a life cycle analysis of FlexBus, determining that it reduces emissions by 90% compared to traditional bus service.

Finally, we present the potential barriers to FlexBus implementation and responses to those challenges. Due to a recently executed labor agreement and other circumstances, the AAATA will not pursue FlexBus at this time. The potential next steps for FlexBus include expanding awareness beyond the AAATA to other public transit agencies. This can be achieved by sharing an explainer video we've completed to spread the word about the concept. A website can be created where information and frameworks contained in this report can be easily accessed by transit agency managers. Finally, the creation of a "FlexBus Calculator" would further assist managers in assessing the potential impact of FlexBus in their system.

Introduction

Background

The Ann Arbor Area Transit Authority (AAATA) provides public transit service to residents in the Ann Arbor and Ypsilanti regions. Since the AAATA is funded by taxpayers, it aims to provide access to all neighborhoods. Tradeoffs of providing access to as many riders as possible are low levels of ridership on certain bus lines and an inefficient distribution of resources. In addition to these spatial constraints, the AAATA is also facing market pressure from the growing use of ride-hail and rideshare services.

Public transit promotes social, economic, and environmental sustainability. We want to ensure that the core values of public transit – safety, affordability, and accessibility - are viable in the future by addressing the challenges and opportunities presented by changes in transportation technology. We want to keep public transit ahead of the transportation technology curve.

Project Goal

Our project, “FlexBus”, partners with the AAATA to enhance fixed-route bus service in the Ann Arbor area through the incorporation of existing ride-hailing technology. The proposed method of integration is to replace underutilized bus routes with subsidized ride-hail services from a transportation network company (TNC) such as Lyft or Uber. We are decidedly TNC-agnostic and believe that the decision to partner with a certain TNC should be made by transit authorities through a transparent, competitive bidding process. The goals of this initiative are to reduce public transit operating costs, improve service to riders, and reduce emissions for a true triple-bottom-line impact. This project will also have the potential to serve as a case study and framework for implementation in other cities throughout the United States.

Project Scope

We structured the project into three main components that are reflected in the organization of this report. First, the research component focused on a literature review of public transit and ride-hail trends in the United States. Second, the design component involved evaluating bus routes for replacement using a custom designed framework as well as subsidy design. Finally, the analysis component includes an evaluation of the potential costs and benefits of the initiative. The implementation of a pilot program was not possible in the project timeline, but could be carried out by the AAATA in 2018.

FlexBus Research

Trends in Public Transit

There are two major contemporary trends that are materially impacting the operations and demands of public transit agencies: 1) the repopulation of urban cores and 2) the increased use of on-demand, geo-spatial ride-hail services.

The rise of suburbanization, beginning in the 1950s, greatly contributed to population decline in America's urban cores. This trend has reversed in recent years; cities are growing faster than their surrounding suburbs (Voith, 2014). This is increasing ridership in cities' public transit systems and, in some cases, overburdening them.

Global Positioning Systems (GPS) and smartphone-enabled transportation services have empowered the private sector to respond to increased demand for transportation services in cities. New services such as bike sharing, ride-hailing, ridesharing, and other forms of high-occupancy taxi services give commuters more options than just personal automobile usage and the public transit system. For example, Lyft Shuttle provides rides for fixed fares along heavily traveled routes that don't currently have a public transit option.

In some instances, public transit has partnered with private companies to enhance their service and/or lower cost (Jerch, 2016). A survey of these are included in our literature analysis.

Trends in Mobility Services

Since Uber was launched in 2009, a number of TNCs have deployed fleets of vehicles to be hailed or shared by paying customers. Uber, Lyft, and Via, just to name a few, offer ride-hailing services through GPS-enabled smartphone apps. Car sharing services, such as Zipcar, Maven, and Getaride, place vehicles in various locations in cities that can be rented by the hour by customers who can access the vehicles with their smartphones and drive them themselves. These services have enhanced mobility for customers and increased the number of options for getting around. Similar to public transit, in many cases these services are much less costly than owning or leasing a personal automobile. As such, they are substitutes to public transit and could impact ridership levels for transit agencies.

Literature Review: Ride-hail Integration with Public Transit

We conducted a comprehensive literature review to understand initiatives already being implemented by public transit agencies to incorporate mobility services. First we present a summary of the literature. Second, we synthesize the literature into options for FlexBus to incorporate. Finally, we examine the AAATA 2015 onboard survey for applicability to FlexBus.

Literature Summary

The integration of ride-hail technology in public transportation increased significantly starting in 2016. This movement kicked off in earnest in early 2016 when the Lynx public transit agency in Altamonte Springs, FL, secured a partnership with Uber to replace its bus service with subsidized Uber rides. The initial success of the 1-year pilot influenced similar programs to be created in other Florida cities and locations around the country.

The incorporation of ride-hail services has been accomplished through both partnerships and in-house initiatives. Altamonte Springs, Boston, and Dallas have all partnered with Uber, while Centennial, CO, and Dublin, CA, have worked with Lyft. For in-house initiatives, transit agencies in places such as Rhode Island and Newark, NJ created their own systems and use their existing assets to operate the service.

The characteristics of the ride-hail service also vary across the pilot programs. Altamonte Springs and Dublin use point-to-point ride-hail to replace underutilized fixed bus routes. Alternately, Newark and San Francisco maintain fixed stops, but instead of running a fixed schedule, they provide on-demand service to avoid operating an empty bus. In a completely different application, Boston uses ride-hail services to replace its costly demand response service that provides rides to disabled riders. Instead of replacing an existing service, Dallas and Centennial, CO use ride-hail to solve the “first-last mile problem” by better connecting riders with existing transit stops. Finally, Pinellas County, FL uses ride-hail to expand its offerings during off-hours when low income residents require transportation to their 2nd and 3rd shift jobs.

A range of subsidy structures are used in the pilot programs. All structures have the goal of reducing the cost to the customer so that it is more in line with typical public transit fares. To accomplish this, some pilots use subsidies in the form of a percentage of the total cost, flat fares, or sometimes even make the service free to promote its use.

The literature cites numerous benefits to these new ride-hail services. These include more mobility options for riders, lower waiting times, reduced costs for the transit agencies, and increased ridership. However, there are also a number of risks, including potentially higher costs to riders, reduced access for low income and disabled people, and loss of union jobs.

A summary of the literature review is provided in **Table 1**. The table includes the city where the ride-hail service integration is taking place, who the public transit agency's partner is, what the service is, the subsidy structure, and the benefits and risks identified by the parties involved. The table is ordered by pilot start date from first to last.

Table 1: Summary of literature review for ride-hail service integration with public transit in order of the program start date

City	Partner	Service	Subsidy	Benefits	Risks	Source
Altamonte Springs, FL	Uber	Feb. 2016 (1 yr pilot): Point to point service anywhere in Altamonte. Replacement for bus routes. Or can use as first-last mile service.	20% (to any location). 25% (to rail station). Estimated to cost $500k.	-Ridership has increased.	-Spiral of death for public transit. -Costs to consumer are higher. -Accommodation of disabled & those without smartphones. -Previous program with Lynx fell through due to cost.	#1, #2
Boston, MA (MBTA)	Uber	Feb. 2016: Demand response service for disabled people (i.e. paratransit). Uses uberWAV service in standard Uber app. Customers have to apply to join program.	2-tiered: Rider pays first $2 then anything in excess of $15	-Reduces cost to MBTA. Previous DR service cost $23 per trip. -Riders don't have to schedule pickup days in advance -Sourcing from TNC allows tech to be updated faster	-Organized labor will oppose job outsourcing -Smartphone penetration -Lack of centralization: coordination between TNC and multiple agencies	#3, #4, #5
Kansas City, MO	Bridj & Ford	Feb. 2016 (1 yr pilot): On-demand point to point service. Use Bridj app to schedule trip. Ford van provides service driven by KCATA employee. Rideshare so routes accommodate all.	10 free trips. Additional rides are $1.50. $1.3M for pilot.	-Quick rerouting and efficient use of resources using the rideshare app.	-Providing drivers good jobs. -Accessibility for all (disabled and those without cell phones or credit cards)... could give 'locked' phones or build kiosks.	#6

City	Partner	Service	Subsidy	Benefits	Risks	Source
Pinellas County, FL	Uber	Mar. 2016 (6 mo pilot): #1: First-last mile service connecting to bus stations. #2: 'Transit Disadvantage' program gives 23 free Uber rides/month between 9 pm and 6 am to eligible low income people. Rides are point to point.	Subsidy for first-last mile service. Free rides for low income at night. Funded by state grant.	-Complement to public transit. -Helps reach low income service workers who work different shifts. -Don't need data plan. Can call Uber over the phone. -Could also apply to paratransit customers.	-Uber labor practices -Passenger safety issues -Skirting of local regulations	#7
Centennial, CO	Lyft Line	Aug. 2016 (6 mo pilot): First-last mile service connecting geo-fenced area to light rail station. Uses Go Denver app for scheduling. Published final report with findings after pilot.	Free ride	-Cheaper than the dial-a-ride service previously used. -Supports aging community. -Had dedicated WAV for disabled -Had call-in service if no smartphone	-Liability and labor issues. -Loss of driver jobs. -Risk of too much demand and run out of money. -People may just use Lyft and kill public transit.	#8, #9
Dallas, TX and Atlanta, GA	Uber	Aug. 2015: First-last mile service connecting to transit station. Access through transit app.	$20 first trip rebate.	-Enhance public transit. -Raises 'coolness' factor of transit.	-Take away public transit customers. -Uber not sharing data so transit agencies can make decisions.	#10
Dublin, CA	Uber & Lyft	Nov. 2016 (1 yr pilot): Replacement of bus routes. Point to point anywhere in project area. Expect 50 riders/day.	Fares capped at $5. Not a fixed % subsidy. $200k available for pilot.	-Eliminate bus route that attracts only 5 riders per hour.	-Union in Dublin is not happy. -More riders may use service than expected and use funds quickly. -Safety since Uber drivers not screened strictly.	#1, #11
Dallas, TX (DART) and Washington DC (Metro)	Lyft	Nov. 2016: Lyft "Friends with Transit" provide last mile	No subsidy listed	-Make transit stops more accessible	-Motivating customer adoption	#12
Rhode Island (RIPTA)	RIPTA Flex Service	Point to point service within the geo-fenced Flex Zone. Service operated by RIPTA. Also connects to transit stops.	Same fare structure as typical bus service	-Provides public transit access to underserved areas	-Reservations required 24 hours in advance -Need to call in a reservation. No app available.	#13
Newark, NJ	AC Transit Flex Service	On-demand fixed route bus service. Can book a pickup on desktop, smartphone, or by calling. Pickup locations are at fixed stops.	Same fare structure as typical bus service	-Reduces wait time for riders -Reduces empty miles and servicing of empty stops	-Need to book 30 minutes in advance -Doesn't work well on out and back loop right. Better for condensed area.	#14

City	Partner	Service	Subsidy	Benefits	Risks	Source
San Francisco, CA & Chicago, IL	Lyft	Lyft Shuttle provides on-demand fixed route service to fixed stops. Includes rideshare for people traveling the same direction. Considered “micro-transit”.	Fixed fare of $3-4. Cheapest option that Lyft offers.	-Right sizes service since uses the Lyft fleet -Smaller wait times -Flex capacity reduces empty miles -Provides service to underserved areas where demand too small for public transit	-Competes with public transit service, although Lyft claims it is a supplement during peak times and in underserved areas	#15

Centennial, CO Case Study

A particularly interesting and applicable case study for FlexBus recently occurred in Centennial, Colorado. The city launched the Go Centennial program in 2016 as a 6-month pilot with a $61,000 budget and the goal of enhancing public transit and reducing congestion. The program consisted of a public-private partnership between the public transit agency and Lyft to provide a ‘last-mile’ service to public transit users. Riders were able to take a free Lyft ride from a light rail station to any point within a specific geo-fenced area.

Overall the pilot was considered to be a successful experiment, although there was lower ridership than expected. Several interesting insights from the pilot are listed below (Centennial Innovation Team, 2017):

- 68% of users had never used dial-a-ride before, indicating they were new to first-last mile service but were willing to try it out
- 36% of users had never used Lyft, indicating users are willing to download a new app
- Of the 200-280 total rides per month, only an average of 9 were booked by telephone
- Each Lyft ride cost the pilot program an average of $4.70 compared to $18 for the previous dial-a-ride service, resulting in significant savings for the city

The Go Centennial program also made several recommendations for other transit agencies who are attempting to create similar programs:

1. Effective marketing is very important to gain ridership.
2. Wheelchair accessible services should be included in any program, but care needs to be taken in the design so that it will be used, otherwise it will turn out to be the single most expensive component of the program. One suggestion is to expand the service area to increase the customer base.

3. Formalized pick-up and drop-off locations should be used instead of point-to-point trips to avoid inefficient routes and confusion in finding locations. Finally, any pilot program should run for longer than 6 months for sufficient trending analysis.

AAATA FlexRide

Another pilot program applicable to FlexBus is the “FlexRide” micro-transit service launched by the AAATA in September 2017 (TheRide, 2017). FlexRide provides $1 rides to the public within a designated area in southeast Ypsilanti township (FlexRide, 2017). It also provides a first-last mile service to Bus Route 46. Metro On-Demand (MODE) was contracted by the AAATA to provide the service, which will also be accessible to riders with disabilities. Reservations can be made either by telephone, online, or through the MODE app.

While FlexRide is similar to FlexBus, there are two main points of differentiation. First, the FlexBus concept focuses on the replacement of an existing underutilized bus route with ride-hail services for triple bottom line benefits. In contrast, FlexRide extends the public transit service to new areas previously not served by the AAATA while also providing a connection to the closest bus stop. The second differentiator is that FlexBus makes use of the existing network of ride-hail services such as Lyft or Uber in order to dramatically reduce costs. This is achieved since at any given moment a Lyft or Uber driver can be servicing a FlexBus request or some other regular trip. In contrast, FlexRide relies on a smaller third party service that does not have an extensive network of drivers and instead would rely on a dedicated vehicle to service the designated area.

Literature Synthesis

The public transit initiatives described in the literature summary provide a framework of options that can be applied to FlexBus. **Table 2** contains the options for integrating ride-hail services into underutilized fixed bus routes.

Table 2: Summary of ride-hail integration options

Ride-hail Integration Option	Description
1. Replacement of Fixed Route with Geofenced Point-to-Point Service: All Day (Peak & Non-peak) or Non-peak	Geofenced point-to-point ride-hail service that replaces a bus route at all times or just during non-peak hours
2. Partial Replacement of Fixed Route with Geofenced Point-to-Point Service: All Day (Peak & Non-peak) or Non-peak	Geofenced point-to-point ride-hail service that replaces a portion of the bus route (typically in outlying suburban areas) at all times or just during non-peak hours
3. Replacement of Fixed Route with On-demand Fixed Route Service: All Day (Peak & Non-peak) or Non-peak	On-demand fixed route service that replaces a bus route at all times or just during non-peak hours. The original route and stops are retained, but they are serviced by either a transportation network company (Lyft Shuttle) or the AAATA when a customer calls it.
4. Partial Replacement of Fixed Route with On-demand Fixed Route Service: All Day (Peak & Non-peak) or Non-peak	On-demand fixed route service that replaces a portion of the bus route (typically in outlying suburban areas) at all times or just during non-peak hours. The original route and stops are retained, but they are serviced by either a transportation network company (Lyft Shuttle) or the AAATA when a customer calls it.
5. Fixed Route Supplement - Low-income: Off-hours	Point-to-point or on-demand fixed route ride-hail service for qualifying low income service workers. Operates during times that bus routes don't run (e.g. 10 pm to 6 am). Can call to reserve ride over the phone.
6. Demand Response (DR) Replacement	DR services (i.e. paratransit or dial-a-ride) replaced by ride-hail with rideshare option to reduce costs. Lyft "Friends with Transit" to partner with cities.
7. First-Last Mile	Ridehail service that connects people to bus stops

Table 3 lists the options for implementing the subsidy for ride-hail services. The table includes example scenarios of how a $3 and $20 ride would be divided up between the rider and the AAATA. The pros and cons of each option are also provided.

Table 3: Summary of ride-hail subsidy options

Subsidy Option	Costs for $3 Ride	Costs for $20 Ride	Pros	Cons
Free ride (i.e. 100% subsidy)	Rider: $0 AAATA: $3	Rider: $0 AAATA: $20	-Promotes use of service -Benefits low income residents	-Too expensive for AAATA
Flat fare (e.g. $5)	Rider: $5 AAATA: $0	Rider: $5 AAATA: $15	-Simple -Limits customer portion	-Customers overpay on short rides -High AAATA expense long rides
Small Subsidy (e.g. 25%)	Rider: $2.25 AAATA: $0.75	Rider: $15 AAATA: $5	-Simple -Helps customer with some of cost	-High user expense for long rides -High AAATA expense long rides
Cap (e.g. $5)	Rider: $3 AAATA: $0	Rider: $5 AAATA: $15	-Simple -Limits cost to customer -Fair to short rides	-High AAATA expense long rides
Small Subsidy with Cap (e.g. 25% & $5): Customer pays 75% of ride up to $5, then nothing after	Rider: $2.25 AAATA: $0.75	Rider: $5 AAATA: $15	-Limits cost to customer -Fair to short rides -Additional subsidy for short rides	-More complex -High AAATA expense long rides
Two Tier Cap (e.g. $2 and $15): Customer pays up to $2 of ride, then anything over $15 cap *Allotted certain number of rides per month*	Rider: $2 AAATA: $1	Rider: $7 AAATA: $13	-Limits cost to customer for short ride -Fair to short rides -Limits cost to AAATA for long rides	-More complex

AAATA 2015 Onboard Survey

The AAATA conducts an onboard survey every two years to gain feedback from public transit users. The most recent survey took place in October 2015 and included responses from 3,383 riders (*Clark et al. 2015*). Statistics contained in the report provide valuable insights on user preferences and trends. We extracted the most applicable statistics from the report and summarized them in **Table 4**. Many of the insights contained in the table reference Routes 33, 67, and 68 since these are the routes focused on in the route selection analysis.

Survey results from the 2017 Onboard Survey should be analyzed for any changes in user behavior and preferences that may impact the adoption of FlexBus. A survey specific to FlexBus was not conducted since these applicable survey data were already available.

Table 4: Insights from 2015 AAATA Onboard Survey (*Clark et al. 2015*)

Title	Statistic	Applicability	Report Figure
Least Used Routes by Riders	•1% of riders use Route 33, 0% of riders use Route 67	•FlexBus should target these underutilized routes	Fig. 19
Rider Type on Routes	•68% of Route 33 riders are Occasional •86% of Route 67 riders are Frequent/Intensive	•Route 33 is better for all day replacement since unpredictable •Route 67 is better for off-peak replacement since predictable	Fig. 20
Uber and Lyft Use	•8% of riders would use Uber/Lyft if bus wasn't available. Most would walk. •75% of riders hadn't used Uber/Lyft in past 30 days. Only 14% used >2.	•FlexBus marketing will have to overcome lack of knowledge of or interest in Uber and Lyft	Fig. 21 Fig. 22
Rider Cell Phone Use	•82% of riders have cell phone with data •14% of riders have cell phone with no data •4% of riders have no cell phone •For those with a phone, 9% rarely text, and 14% rarely access the internet •56% of riders use Track My Bus •Younger riders use smart phone more than older riders •All statistics have increased since 2013: 51% to 82% smartphone use	•Large majority of riders can use FlexBus on their phones. However, there are still some riders without cell phones that will have to be accommodated. •These no cell phone riders will continue to decrease •Target younger neighborhoods to avoid cell phone barrier	Fig. 55 Fig. 56
Rider Dissatisfaction	•Frequency of service & on time performance have highest dissatisfaction	•FlexBus will target these pain points	Fig. 44
Low Income Riders	•57% of all riders make <$25,000 •26% of riders use cash •4% of riders are unemployed •9% of riders get discounts due to their low income status	•FlexBus will have to accommodate the significant portion of riders who are low income and rely on cash •The riders who get discounted fares would have to be accounted for in the service with further subsidies	Fig. 35 Fig. 16 Fig. 26 Fig. 18
Rider Language Barrier	•3% of riders admit to not speaking English well	•FlexBus will have to accommodate those who can't speak english	Fig. 42

Title	Statistic	Applicability	Report Figure
Rider Proximity	•65% of riders live within 5 minutes of a stop	•FlexBus geo-fence wouldn't have to be that big to incorporate most riders of that route	Fig. 14
Rider Age	•73% of riders are <40 years old	•Young ridership should be familiar with smartphones	Fig. 30
Rider Household Size	•60% of households are 1-2 people	•Not as much inherent ride sharing can be expected on FlexBus since most aren't traveling together	Fig. 38
First-Last Mile	•88% of riders walk to the stop	•A point-to-point service would be attractive to many users	Fig. 13
Rider Experience	•51% of riders have ridden AAATA for less than 2 years	•Most people are new to AAATA programs, so introducing something new may take a lot of marketing	Fig. 6
Rider Continuity	•83% of riders said they will continue riding next year	•Effective marketing of new program now will pay dividends down the road with continuous users	Fig. 9

Primary Research: Partnering with a TNC

We wanted to learn from the experience of a TNC who is engaged in a partnership with a transit agency and understand the logistics of how a partnership would work. For that, we managed to arrange a phone call in June with Uber, which is the private TNC with the most experience in this field. We spoke to Uber's Strategy and Planning Lead as well as the marketing manager with a strong background in Transit Partnerships.

Feedback from existing partnerships

Uber has worked with many cities and welcomes the AAATA to discuss a partnership. Most transit agencies begin relationships with a Pilot project. Uber recommends at least 6 months for the duration of the pilot in order to collect sufficient data to measure success. It claims that partnerships have generated more positive public relations than negative. Finally, it emphasized that cities have saved significant costs by replacing Demand Response/Dial-a-Ride service with Uber. Uber also stated that resistance from unionized labor is inevitable in partnerships it has engaged in with transit agencies, but that the benefits to riders of these partnerships overwhelm the costs.

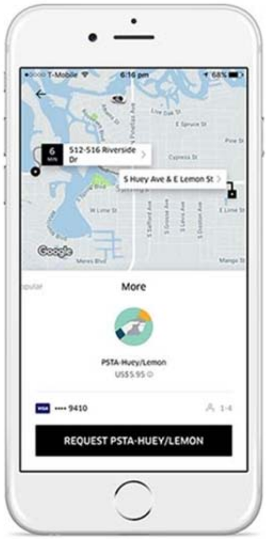
Ann Arbor Ride Data

Uber indicated the average fare in Ann Arbor was $11-12. They also provided data on average wait time, which is under 4 minutes when school was in session and under 5 minutes when school was not in session.

Logistics of Integrating Service Into Smartphone App

As a leading tech company, Uber can create tailor-made tech solutions for transit agencies case-specific needs. There are two options to trigger a transit subsidy within their app: 1) Uber can recofnize qualifying rides based on time, location, and rider characteristics, prompting rider with a subsidy option (See **Figure 1** below from Uber’s partnership with Pinellas County). 2) qualifying riders can be issued Promo codes that can be entered into the app

Figure 1: Screenshot of Uber subsidy in its partnership with Pinellas County, FL



Legal Considerations

The documentation requirements of a partnership depend on where the funding comes from. Different government levels have different contractual requirements. However, pilots and proofs of concept partnerships can be documentation-lite. They have done RFPs, but try to avoid that due to the involved cost and timing.

FlexBus Design

Ride-hail Service Design

There were seven integration options identified in **Table 2**. We used the following criteria in deciding from those options:

- Accessibility - All residents in the service area should be able to access the service.
- Simplicity - The service should be simple for residents to understand and use.
- Ease of Implementation - The service should be as close as possible to a “turn-key” package for AAATA’s immediate use. Disruption to existing operations should be minimal
- Time Savings - The service should minimize wait time for riders.
- Environmental Benefits - The service should reduce life cycle emissions.
- Cost Savings - The service should save money without increasing customer costs.

Ultimately, the first option - replacement of an entire fixed route for the entire day with geofenced point-to-point service - best satisfied the above criteria. We also considered partial day replacement, as higher demand during rush hour commuting could benefit from the high capacity of buses while low ridership off-peak hours don’t. However the optimal bus route we selected for FlexBus does not have significantly higher variability during peak hours; ridership is low throughout the day, so bus service is never justified in our view.

With the first option, affected customers within the area that was previously served by the bus would have the option to hail a ride to any point within the geo-fenced area. If the passenger’s final destination lies within the geo-fenced area, then she can be driven to that destination. If the final destination lies beyond the geo-fenced area, then she can be driven to a junction with another bus route, where she could validate with a bus driver that she had taken an AAATA-approved service that is eligible for bus transfer to continue her journey by bus. We determined that the geo-fenced area should include all areas that are acceptable distance of the affected bus route -- that distance varies by city between 0.25 and 0.5 miles (Walker, 2011).

Subsidy Design

There are trade-offs associated with the different options for subsidy structures outlined in **Table 3**. For example, a flat fare is simpler for riders, but leaves the transit agency with unknown and limitless subsidy amount. On the other hand, a flat cap limits the subsidy amount for the transit agency, but leaves the rider with uncertainty in cost. There is no subsidy design that provides certainty in cost for both the rider and the transit agency. Unless the TNC agrees to fixed ride prices, which is seldom the case in the private market today, either the rider, the transit agency or both must tolerate uncertainty in cost.

We believe that certainty in cost for the rider is most important, especially as a means to familiarize riders with a new service. FlexBus may seem exotic and possibly intimidating to passengers who are unfamiliar with ride-hailing using smartphone technology. Uncertainty in cost should be avoided in order to ease communication of the new service to passengers.

We recommend the Flat Fare subsidy option in **Table 3**. The fare should be set to the prevailing fare for other rides in the transit system to further improve communication and to provide equity to passengers across the system. For the AAATA, that fare is $1.50.

A flat fare exposes the transit agency to risk of increased costs with no ceiling. If costs arise to an intolerably high level, the transit agency always has the option to cap the subsidy, however that would negate the communication and equity benefits of the flat fare.

Route Selection Methodology

General Description

The main idea of FlexBus stems from the fact that within a traditional bus-based transit system, there exists situations where non-traditional transit services would provide greater value to riders and taxpayers than the status quo. Specifically, the strategy of FlexBus is to replace under-utilized bus routes with on-demand ride-hail services to reduce the inefficient spending of taxpayer dollars and provide service with a higher quality for the users. We are sensitive to the fact that changing a system designed to serve all citizens equally could lead to concerns of unfairness in decision-making. For this reason, any change to the public transit system that everyday users rely upon must be thoughtful, demonstrably better than the current system, and well-communicated to users of the current system.

As a corollary to the aspirations and concerns outlined above, not all routes are suitable for this strategy. For instance, we believe that it would not be beneficial to initially implement FlexBus on a heavily utilized bus route during the rush hour. Thus it is essential to identify which routes are most suitable for this new service and to rank them so that if only a few are to be selected - particularly relevant for a pilot program - the best routes are selected.

The fact that FlexBus would affect the everyday lives of users was front of mind for this team. The potential for negative impacts caused by miscommunication or the glitches inherent to the roll out of any novel product or business model certainly exists, but are often errors in execution. Because of the potential for analysis paralysis which could occur from attempting to provide guidance to employees for every anticipated tactical-level scenario, and because we do not pretend to fully understand the dynamic social environment that AAATA employees successfully navigate on a daily basis, we instead decided to focus on route selection. In the spirit of full transparency during the pre-execution route-selection process, the FlexBus team conducted multi-criteria decision-making (MCDM), outlined below.

Sources of Data

To help us select the optimal routes for FlexBus implementation, the AAATA provided us with two sets of data. In the first set, ridership data was provided in two formats: a general longitudinal survey of ridership and a concise, month-long observation period. The longitudinal database contained data such as average passenger per service hour for 5 consecutive years, 2012 to 2016. The month-long case contained monthly average values of ridership data for weekdays in January 2017 for each individual route. The second data set was more detailed, containing dimensions unmeasured in the first set, and thus was more extensively used for route selection.

Our first wave of selection narrowed it down to three routes. Then the AAATA provided us with more detailed data on those three routes that included average ridership for different hours of operation during the day which was useful to assess demand variability to identify the exact hours for which the route was underutilized.

Narrowing Down the Search

The most suitable routes for FlexBus implementation are those that are underutilized during certain hours of operation. Hence, those routes with high ridership levels can be crossed off the list of potential candidates for FlexBus. Initially, we narrowed down the list to three routes (33, 67, and 68) due to their low ridership levels. Although three routes were selected in our initial phase, there is no reason to specifically select three routes, and depending on the network, higher or fewer number of routes could be selected. The key issue is to select those that have significantly higher potentials than others. Limiting the rest of analysis to three routes helped the team to prevent the transfer of unnecessary information from the client. Later on, more detailed data on these three routes enabled us to produce a final recommendation.

Bus Route Trade Matrix

After the three FlexBus candidate routes were identified, we ranked them in order to enable selection of the best route(s) for FlexBus implementation. As it will be discussed later in the report, our financial analysis shows that the cost saving potential of FlexBus varies depending on the ridership level of the bus route in consideration. The lower the ridership level, the greater the cost saving potential for the AAATA. However, the anticipated scenario is that if FlexBus was ever to be implemented, it would be done so by implementing it (potentially as a pilot) on few or just one route and ranking them would enable the selection of best candidates.

We used the MCDM, also known as the Pugh method (Pugh, 1981), to rank the three routes. In this technique, different decision-making criteria are ranked based on their importance and weights are assigned such that more important criterion would receive higher weight. Furthermore, each option is given a score for each criteria and the score is given by comparing it with other options. For each criterion, the matrix assigns a score of 10 to the best option and a score of 0 to the worst and the options in between are assigned scores linearly based on their raw values. In mathematical words, if x_{best} is the raw value for best option and x_{worst} is the raw value for the worst option, for an option with raw value of x the score s is calculated via **Equation 1**:

$$\frac{x-x_{worst}}{x_{best}-x_{worst}} = \frac{s-0}{10-0} \quad (1)$$

The final score of each option is the weighted sum of its scores over all individual criteria. If the weight of the i-th criterion among total number of n criteria is w_i and the score of the j-th option under the i-th criterion is s_{ji} then the final score of j-th option, S_j , is calculated by **Equation 2**. An option with higher score is a more suitable option for the decision at hand.

$$S_j = \sum_{i=1}^{n} w_i s_{ji} \quad (2)$$

After careful discussions, the team included a total of five criteria for deciding route ranking and assigned weights to those criteria accordingly. The weight assignment process is subjective and for a different scenario, a different set of weights could be assigned. The most important criterion was utilization (riders per hour) to which a weight of 40% was assigned. The lower the ridership of a route, the better that route is for FlexBus. Next was the demand variability (i.e. the standard deviation of hourly ridership values) and a weight of 25% was assigned to this criterion. For the scenario of implementing FlexBus for the entire day (which is the current scenario), lower demand variability is better since during the day, demand is more uniformly distributed and this eases the maximum load on ride-hail system that is to be used. If the route is to be replaced with FlexBus only during certain parts of the day, then higher demand variability is better since this would indicate that there are off-peak times during the day when demand is significantly lower than average demand so the implementation time can be distinguished and selected more conveniently. Third criterion is ride-hail system availability and it is assigned a weight of 15%. The ride-hail service availability of each route was evaluated by randomly measuring the estimated wait time (EWT) for a ride from a TNC app at different locations in the geo-fenced area of the route during different times of day. The average value of the EWTs for each route was then selected as the raw feature. Lower EWT implies higher availability of ride-hail service, therefore enhancing rider experience, which is a crucial reason to implement FlexBus. Finally, two items were given equal weights of 10% each; route overlap and route distance. Overlap with fewer routes and lower route length simplifies the implementation of FlexBus.

Results

The data for January 2017 contained daily average values of different ridership parameters as well as data for morning, midday and afternoon peaks. For the utilization metric, we used the sum of total number of people that get off the bus at each stop (alight) for the entire route.

Figure 2 shows the alight values for candidate routes. The yellow bars correspond to average alight values for that route and the blue bars, called minimum peak values, are the minimum alight value between the three values corresponding to morning, midday and afternoon peaks. As it can be seen, routes 67, 68, 26, 21 and 33 have lowest average utilizations. Due to complex geometry and overlap with other routes, routes 21 and 26 were dropped out of the potential candidates and routes 33, 67 and 68 were selected for further analysis. Route 21 specifically was located at central campus where many businesses and restaurants were located and this fact made anticipating the exact value of ride-hail subsidy users difficult and added a layer of uncertainty to results.

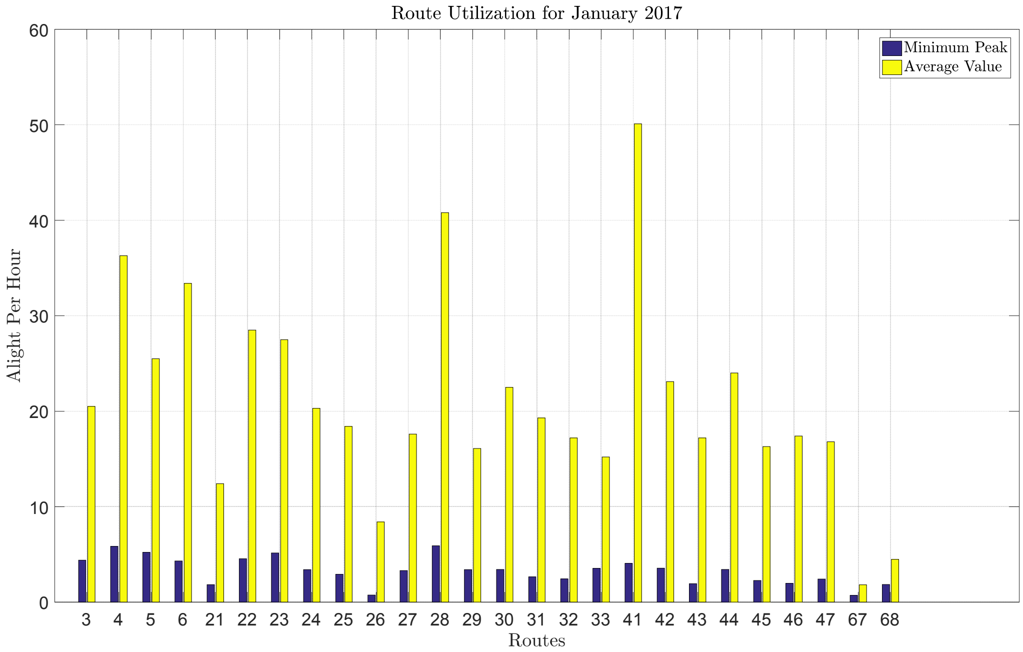
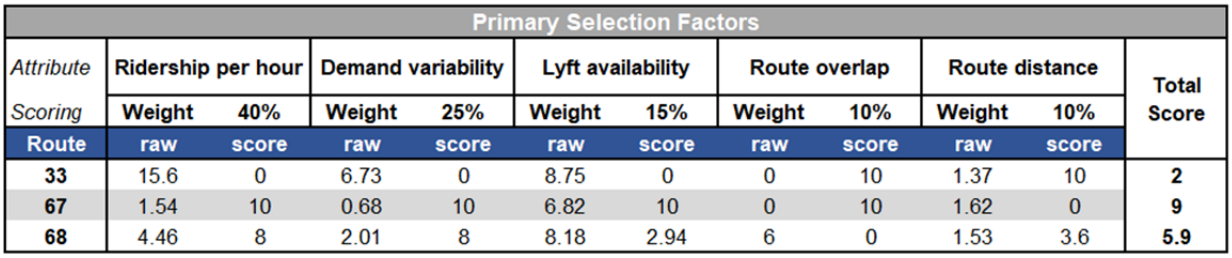


Figure 2. Total and minimum peaks alight values for routes. Minimum peaks values are the minimum value of AM-Peak, Midday Peak and PM-Peak alight values.

Table 5 shows the decision matrix for the three candidate routes. Based on the scores provided, it can be seen that route 67 is the best candidate followed by route 68.

Table 5: Decision-matrix for candidate routes



Primary Selection Factors											
Attribute	**Ridership per hour**		**Demand variability**		**Lyft availability**		**Route overlap**		**Route distance**		**Total Score**
Scoring	**Weight**	**40%**	**Weight**	**25%**	**Weight**	**15%**	**Weight**	**10%**	**Weight**	**10%**	
Route	**raw**	**score**	**raw**	**score**	**raw**	**score**	**raw**	**score**	**raw**	**score**	
33	15.6	0	6.73	0	8.75	0	0	10	1.37	10	**2**
67	1.54	10	0.68	10	6.82	10	0	10	1.62	0	**9**
68	4.46	8	2.01	8	8.18	2.94	6	0	1.53	3.6	**5.9**

Discussion

Figure 2 shows that ridership for each bus route is higher during certain parts of the day (rush hour, for example) and lower ridership during other parts (off-peak hours). This strikes to the core of FlexBus' value proposition, that public bus systems offer fixed bus service that's underutilized and inefficient at certain times and on certain routes; more efficient service is possible if on-demand ride-hailing is used. Although we ultimately recommended full route replacement with FlexBus, we used the average utilization rates across different parts of the day in **Figure 2** to narrow down the search.

Generally, the data used for **Figure 2** are consistent with those data provided by AAATA in the longitudinal dataset. Miniscule errors exist due to rounding errors in January 2017 dataset due to the fact that this data set was provided in PDF format and values were shown as integers only. Furthermore, for this dataset, there existed a few missing data points for different bus stops which also contributed to the slight errors.

In **Table 5,** Route 67 showed to be the most suitable option under all criteria except for route length. If an option outperforms all other options under all criteria, that option would receive a score of 10. Given the numbers, if a pilot project was to be implemented in order to replace a route for the entire day, the FlexBus team recommends route 67 for this pilot.

Options for On-demand Service Provider

The essence of FlexBus is that buses are not nimble enough to cost-effectively cover lower-density areas. In order to reduce inefficient bus service and improve service for riders, on-demand hailing of passenger vehicles or shuttle vans is required. We are agnostic to the provider of this service and recommend procurement in accordance with transit agency's policies. Potential options include TNCs such as Lyft and Uber or an in-house service. The following criteria should be considered in an RFP:

- Availability of smartphone app with GPS-based ride-hailing feature
- Low cost
- Ample supply of drivers to provide rides
- No minimum ride requirements; transit agency only pays for rides taken by passengers
- Reputation with the public
- Options available for passengers with disabilities
- Vetting process, including background checks, for drivers

FlexBus Analysis

Financial Analysis

An important aspect of FlexBus is that it can have a neutral or downward cost impact. If the FlexBus program is cost accretive, then it should provide ample public benefit to justify increased cost. Although we cannot predict with certainty whether FlexBus implementation will result in cost savings for the AAATA, we can estimate cost savings of curtailing fixed bus service, the size of the subsidy cost, and the number of subsidized rides taken by passengers. The following calculations let us estimate the net cost effect of FlexBus. We relied on some data from Uber in order to make the calculations.

Cost Savings

We applied cost data from the AAATA to the estimated amount of suspended fixed bus service. We then cross referenced our findings with peer agencies and academic research.

AAATA

The following analysis is from the AAATA's 2017 fiscal year operating budget for fixed bus service. Of the $33.3 million budget, $26.2 million is variable with hours of fixed bus service. As there are 279,900 hours of fixed bus service, the estimated cost of a marginal hour of service is $93.61. Therefore, each hour of bus service suspended and replaced with FlexBus service represents $93.61 of cost savings. These calculations are summarized in **Table 6**.

The breakout of the $93.61 variable cost is as follows: 79.6% is personnel-related, 6.4% is related to fuel and gasoline, and 14.0% is related to other variable costs, including insurance, bus depreciation, and other materials and supplies. This finding is consistent with academic research from Jarrett Walker, who finds that driver labor and related time-based costs represent over 70% of typical transit agencies' operational costs (Walker, 2011).

Table 6: Derivation of FlexBus cost savings from FY17 AAATA Fixed Route Operating Budget

Category	Fixed Route	Variable?	Total Variable Cost
Operations	10,875,136	Y	10,875,136
Maintenance	3,146,619	Y	3,146,619
Administrative	2,185,963	N	-
Fringe Benefits	6,840,207	Y	6,840,207
Personnel Subtotal	23,047,925		20,861,962
Purchase Services	2,714,018	N	-
Diesel Fuel	1,676,244	Y	1,676,244
Materials & Supplies	2,590,978	Y	2,590,978
Utilities	515,460	N	-
Casualty & Liability Insurance	827,222	Y	827,222
Purchased Transportation	-	N	-
Other Expenses	680,407	N	-
Local Depreciation	245,000	Y	245,000
Other Subtotal	9,249,329		5,339,444
GRAND TOTAL	**$32,297,254**		**$26,201,406**
Hours of Service			279,900
Variable Cost of 1 Hour of Fixed Bus Service			**$93.61**

Peer Group

The median operating cost per hour of service for cities with populations less than 1 million is $75.52, according to the National Transit Database. The 25th-75th percentile range is $60.83 - $92.74. This suggests Ann Arbor's hourly cost is close to the 75th percentile. Considering the relatively high cost of living in Ann Arbor for a city under 1 million in population, this is reasonable.

Limitations on Cost Savings

Terms of labor contracts with bus drivers may limit the amount of marginal costs savings possible. For example, contracts may require bus drivers' shifts be no less than 8 hours, or it may limit the number of "split runs" ("Split runs" partition driver duties into multiple pieces for a given route, as opposed to a "straight run" where a driver works a continuous eight-hour shift) (Jerch, 2016). We assumed, however, that a curtailed hour of bus service is associated with $93.61 of cost savings for the AAATA, as we were not privy to terms of labor contracts.

Lost revenue

Each hour of suspended service results in lost revenue in the form of forgone fares paid by riders. According to the AAATA, the average fare is $1.19. In our pro-forma financial impact analysis, we will incorporate lost revenues for each of the proposed pilot routes.

Subsidy

Each hour of FlexBus service requires payment of the ride subsidy by the AAATA to the ride-hail provider. We estimated the average size of the subsidy based on information provided by Uber. Uber has more data on rides in Ann Arbor than any other private company, so it was the best available information. According to Uber data, the average ride cost within Ann Arbor is $11-12. However, since rides would be limited to the geo-fenced area, we used $6 as the average cost of a ride. Per our proposed flat-fare subsidy structure, $1.50 of each ride would be paid by the customer and the remaining by the AAATA. Therefore, each subsidy would cost the AAATA, on average, $4.50.

Table 7: Financial Summary

(expressed in USD per hour)	**Route 33**	**Route 67**	**Route 68**
Cost savings	$93.61	$93.61	$93.61
# of passengers per hour	15.6	1.54	4.46
Lost revenue per passenger*	$1.19	$1.19	$1.19
Lost revenue	$18.56	$1.83	$5.31
Net savings of suspended bus service	**$75.05**	**$91.78**	**$88.30**
Average number of riders per hour	15.6	1.54	4.46
Average subsidy cost	$4.50	$4.50	$4.50
Total subsidy cost	$70.20	$6.93	$20.07
Net financial savings of FlexBus	**$4.85**	**$84.85**	**$68.23**
# of FlexBus rides self-financeable	16.7	20.4	19.6

*The AAATA informed us that $1.19 is the average revenue received per passenger ride

Environmental Analysis

We conducted a process-based and attributional life cycle assessment (LCA) to determine the environmental impacts of FlexBus in accordance with the ISO 14040 standard. The life cycle phases included are materials production, manufacturing and assembly, use, and end of life treatment. We organized this section as follows: goal, scope, methodology, and results.

Goal

The goal of this LCA is to estimate the environmental impacts of completely replacing fixed route bus service with on-demand ride-hail service during both peak and non-peak hours.

Scope

The scope of the LCA includes a comparative analysis between fixed route bus service and on-demand ride-hail service within 10,000 scenarios contained in a Monte Carlo simulation. The scenarios involve variation of powertrains, route characteristics, customer demand, and vehicle availability.

Product System

The first product system used in the comparative analysis is the fixed route bus service currently operating on Route 67. The route is classified as a non-loop route and has a round trip distance of 13.4 miles with an average of 27 riders boarding per day on 12 trips across its 36 separate stops (*Ridecheck Plus 2017*). Two types of buses operate on Route 67: a Gillig conventional diesel bus and a Gillig hybrid bus. The AAATA fleet is fairly new with an average age of 2 years and is composed of 46% conventional buses with average fuel economy of 4.3 mpg and 54% hybrid buses with average fuel economy of 4.8 mpg (*Terry 2017*).

The second product system is the on-demand ride-hail service provided by an existing TNC such as Uber or Lyft. The service is constrained by a geo-fence that includes the area within 0.5 miles of Route 67. Point-to-point rides can be taken anywhere within the geo-fenced area. Riders will hail a ride and the TNC vehicle will travel from its current position to the desired pickup location. The distance traveled during this segment of the trip is considered “empty miles” since no passenger is being transported. Three TNC vehicles were included to represent the range that could occur in the real world. The three vehicles are the Chevy Trailblazer SUV, Toyota Camry sedan, and Toyota Prius hybrid.

Functional Unit

The functional unit focuses on the service provided to the customer with 27 passengers serviced per day in randomly generated pickup and drop-off locations along Route 67. The 27 passengers was also varied by +/-20% to determine the sensitivity of the results to demand.

System Boundary

The system boundary includes all life cycle phases and processes in accordance with the ISO 14040 standard. Life cycle burdens include both the direct and indirect processes and services required to operate the vehicle. This includes raw materials extraction, manufacturing, construction, operation, maintenance, and end of life of vehicles, infrastructure, and fuels.

Environmental Impact Indicators

Four indicators are provided in this analysis based on their importance in automotive sustainability assessments (*Jasinski et al. 2016*). The first is cumulative energy demand (CED) in units of megajoules [MJ]. The second is global warming potential over 100 years (GWP) in units of kilograms of carbon dioxide equivalent [kg CO2-eq]. The third indicator is life cycle sulfur dioxide emissions [SO2] in units of grams. Finally, nitrogen oxide and nitrogen dioxide [NOx] emissions are included in units of grams.

Methodology

The impact data per person kilometers traveled (PKT) contained in **Table 8** were sourced from a previous life cycle study of transportation modes (Chester & Horvath 2009).

Table 8: Impact data from Chester & Horvath 2009 study

Transportation Mode	CED (MJ/PKT)	GWP (kg CO2-eq/PKT)	SO2 (mg/PKT)	NOx (mg/PKT)
Conventional Bus	5.4	0.415	230	2750
Hybrid Bus	5.0	0.384	229	2520
Chevy Trailblazer	4.0	0.280	250	550
Toyota Camry	2.9	0.235	215	530
Toyota Prius	2.0	0.164	210	382

The data were converted to impact per mile using the assumptions contained in **Table 9** from the Chester & Horvath 2009 study and assuming buses and vehicles have total lifetimes of 500,000 and 160,000 miles, respectively (*Laver et al. 2007*).

Table 9: Bus and vehicle characteristics used in modeling

Transportation Mode	Load Factor (Persons)	Lifetime (Years)	Use (Miles/Year)
Bus	5.00	12.0	42,000
Chevy Trailblazer	1.74	15.5	11,000
Toyota Camry	1.58	16.9	11,000
Toyota Prius	1.58	16.9	11,000

The resulting life cycle impact data in terms of impact per mile are contained in **Table 10**.

Table 10: Impact data in terms of impact per mile

Transportation Mode	CED (MJ/mile)	GWP (kg CO2-eq/mile)	SO2 (mg/mile)	NOx (mg/mile)
Conventional Bus	43.80	3.37	1865	22305
Hybrid Bus	40.42	3.12	1861	20446
Chevy Trailblazer	11.94	0.84	746	1641
Toyota Camry	8.57	0.69	635	1565
Toyota Prius	5.81	0.49	620	1130

We used two separate frameworks to model the two product systems due to their inherent differences. The bus framework determines the total daily impact by taking into account the number of trips, the route distance, and the life cycle impact per mile. The ride-hail framework uses the IPAT equation that calculates impact by taking into account the population (or number of boardings per day), affluence (or distance traveled per passenger), and the technology (or life cycle impact per mile). The details of each framework are provided in **Table 11**.

Table 11: Summary of the bus and ride-hail framework used in the environmental analysis

Bus Framework: I=NRT
I: Impact… total life cycle energy [MJ/day], global warming potential [kg CO2e/day], SO2 [g/day], or NOx [g/day]
N: Number of Trips… number of trips per day [trips/day]
R: Route Distance… distance of one route cycle [miles/trip]
T: Technology… total life cycle energy per mile [MJ/mile], global warming potential [kg CO2e/mile], SO2 [mg/mile], or NOx [mg/mile]
Ride-hail Framework: I=PAT
I: Impact… total life cycle energy [MJ/day], global warming potential [kg CO2e/day], SO2 [g/day], or NOx [g/day]
P: Population… number of boardings per day modified by the capacity factor (not including driver) to account for rideshare [passengers/day]
A: Affluence… distance traveled per passenger and empty miles traveled by ride-hail to pick up passenger [miles/passenger]
T: Technology… total life cycle energy per mile [MJ/mile], global warming potential [kg CO2e/mile], SO2 [mg/mile], or NOx [mg/mile]

We ran a Monte Carlo simulation using the frameworks described above. The input parameters we used are provided in **Table 12**. Each parameter has a minimum, most likely, and maximum value that are used to create a triangular random distribution for use in the Monte Carlo. The rationale for the ranges are provided in the table.

Table 12: Input parameters for each framework used in the Monte Carlo simulation

Parameter	Min	Avg	Max	Rationale
N: Number of trips [trips/day]	11	12	13	Varied AAATA avg data by +/-1
R: Route Distance [miles/trip]	13.4	13.4	13.4	Calculated from Google Earth
P: Population [riders/day]	22	27	32	Varied AAATA avg data by +/-20%
P: Capacity Factor [riders/vehicle]	1.0	1.2	4.0	Avg assumes most riders travel alone
A: Affluence [miles/rider]	0.5	3.4	6.7	Min is typical walkable threshold Max is end to end route distance
A: Affluence [empty miles/rider]	0	1	3	Reasonable considering city size
T: Bus - Energy [MJ/mile]	40.6	42.2	43.8	Min is conventional diesel bus Max is hybrid bus
T: Bus - GWP [kg CO2e/mile]	3.1	3.3	3.4	
T: Bus - SO2 [mg/mile]	1865	1868	1871	
T: Bus - NOx [mg/mile]	20561	21433	22305	
T: Ridehail - Energy [MJ/mile]	5.8	8.6	11.9	Min is Prius Avg is Camry Max is Trailblazer
T: Ridehail - GWP [kg CO2e/mile]	0.5	0.7	0.8	
T: Ridehail - SO2 [mg/mile]	620	635	746	
T: Ridehail - NOx [mg/mile]	1130	1566	1641	

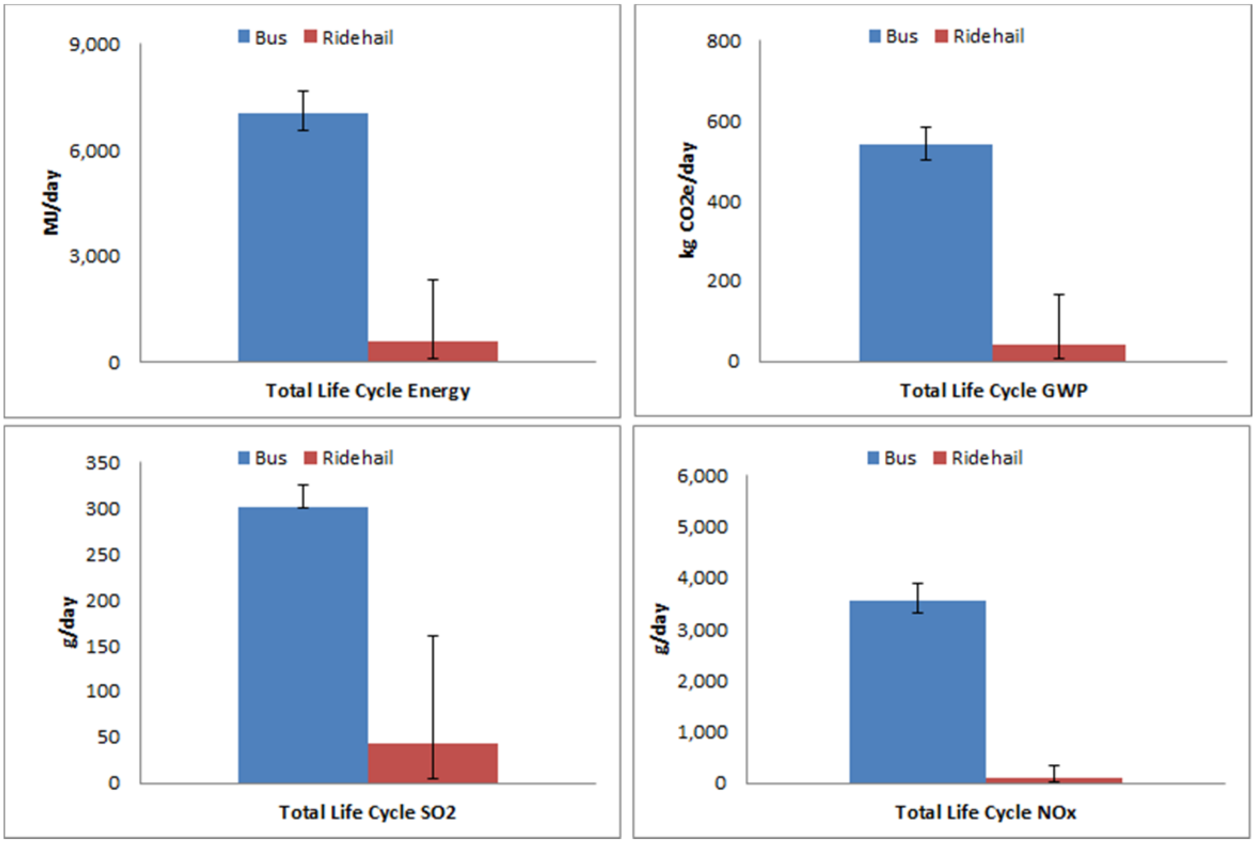
Results

The environmental analysis results are contained in **Table 13** and displayed in **Figure 3** below. The fixed route bus service and on-demand ride-hail service are compared for each environmental impact indicator on a per day basis. The solid columns represent the average produced by the Monte Carlo analysis while the error bars indicate the min and max ranges.

Table 13: Environmental analysis results for each of the four impact indicators

Impact	**Bus**			**Ride-hail**		
	Min	**Avg**	**Max**	**Min**	**Avg**	**Max**
CED [MJ/day]	6542	7030	7627	80	568	2299
GWP [kg CO2e/day]	504	540	586	5	43	167
SO2 [g/day]	300	301	326	4	44	161
NOx [g/day]	3311	3569	3884	12	93	340

Figure 3: Environmental analysis results for four impact indicators: energy demand (top left), global warming potential (top right), sulfur dioxide (bottom left), & nitrogen oxides (bottom right)



The on-demand ride-hail service shows significant reductions in all four environmental impact indicators when evaluated in terms of average impacts. When looking at the average scenario within the Monte Carlo, the decrease between the bus and ride-hail results for CED, GWP, SO2, and NOx are 91%, 92%, 86%, and 97%, respectively. However, large uncertainties exist that indicate the bounds of potential outcomes. At one extreme, environmental impact in terms of

GWP could be reduced by nearly 99% when the bus service is replaced by FlexBus. At the other extreme, the impact would only decrease by 67%. Therefore the most likely outcome of FlexBus is a reduction in energy and emissions on the order of 90%.

The following three guiding principles should be followed in order to maximize environmental benefits. First, use efficient hybrid vehicles within the ride-hail service to minimize energy consumption per mile. Second, reduce empty miles to the extent possible by strategically positioning the fleet assets around the geo-fenced area to minimize the distance needed to travel to pick up a passenger. Finally, promote ride sharing among riders so that trips can be combined and total vehicle miles traveled can be decreased while providing similar service.

Overall, FlexBus offers the opportunity to significantly reduce the environmental impact of public transit by right-sizing services and more efficiently matching supply with demand.

Community Impact Analysis

The FlexBus team was unable to complete a survey of AAATA riders due to concerns of user survey fatigue by the AAATA. However, concerns regarding the following situations were constantly, and often emotionally, discussed by the group members.

Equal Access

In order to access FlexBus service, users need access to a smartphone with data or wifi service and a payment method that’s linked to their transportation network company account. This presents a potential problem, as **Table 4** demonstrates that a significant albeit shrinking percentage of AAATA riders don’t have access to a smartphone and a portion of the population don’t have the bank account or credit account needed to open an account with a TNC.

Uber and Lyft have responded to this barrier to access by offering features that allow remote hailing of rides using a different payment account. Using “Uber Central,” a transit agency can take phone calls from users who don’t have access to a smartphone and use a centralized account to hail the ride for them. To pay for these rides, a transit agency can use their own account. While this solution is not as speedy and seamless as the status quo, it will still get passengers a pickup quicker than a bus and with likely less hassle.

Disabled riders

Public buses are required to be accessible to people with disabilities per the Americans with Disabilities Act. FlexBus service should also cater to riders with disabilities. The ride-hail service provider selected to provide FlexBus service should present its abilities to supply wheelchair accessible vehicles.

On the other hand, by picking up passengers at their door, FlexBus breaks down one barrier to access to the public transit system, which is the journey from a riders current location to the nearest bus stop.

Safety

Vulnerable populations, including women, could be wary of entering a car with a stranger for a ride. This concern could render FlexBus service inaccessible. It’s important in the marketing of FlexBus to emphasize the safety and transparency inherent in ride-hail services. Each ride is tracked by GPS and the ride-hail service provider has a record of the driver and passenger for each ride, including contact details and home addresses. This transparency is a deterrent to potential bad behavior from both the driver and passenger. This transparency in ride-hail services, however, is not intuitive and must be communicated to the unfamiliar public.

Unfamiliarity of use

Potential users of FlexBus could be deterred because they have never hailed a ride before and/or have general technology anxiety. One solution to tech anxiety is the user could use their landline phone to hail a ride through the transit agency’s central dispatch. However, we believe that FlexBus does the public a service by introducing parts of the public to technology who might otherwise not become familiar. Initial discomfort can be replaced with empowerment of services available to them through technology.

Political Analysis

FlexBus represents change from the status quo, which is always hard. We have some recommendations related to the framing of this initiative that we believe will help to overcome the potential resistance to change.

The first recommendation is to emphasize the benefits of the initiative. The marginal benefits of FlexBus include improving service for affected riders, cost savings for the public transit agency, environmental benefits due to less emissions, and an improved perception of public transit for embracing technology. These benefits act to offset the costs of bus driver labor impacts.
The second recommendation is to focus on the scarcity of funds for public transit. It is important that these precious dollars not be wasted on empty bus service if a better solution exists.

The third recommendation is to avoid using the “Uber”. FlexBus is agnostic to the 3rd party provider of ride-hail services. Although it's tempting to mention Uber due to its name recognition and broad familiarity with the public, it ultimately could do you a disservice due to it’s recent image problems. Instead, we should mention that there are many private firms that offer ride-hailing services and the transit agency will partner with the one that could best service the community.

Finally, it is important to avoid using the word “replace.” Proponents of public transit and politicians wary of political backlash will be wary of replacing unionized, public sector labor with non-unionized private sector labor. Instead, emphasize that FlexBus can efficiently cover sparsely-populated areas that buses cannot.

Recommendations

We recommend that the AAATA pursue a one-year FlexBus pilot program as soon as the labor contract cycle will allow. The pilot should take place in the area currently covered by route 67 on a full time basis. FlexBus service in this area is expected to save the AAATA up to $85 per hour while dramatically improving access to the AAATA bus network for residents in the affected area. Additionally, FlexBus is expected to cut vehicle emissions by 90%.

The focused scope of the project limits risk of cost overruns and allows AAATA to assess the public’s response and the empirical results of FlexBus. It also provides the AAATA experience with tech-enabled mobility services, which is crucial as the competitive landscape for mobility services continues to become more crowded and diverse.

Future Work

The potential next steps for FlexBus include expanding awareness beyond the AAATA to other public transit agencies. We believe this can be accomplished through three main outreach avenues that could be implemented by a future Dow Sustainability Fellowship team, if interested. The first is to share an explanatory animation that we developed through social media and other online platforms. The second avenue is to create a website where information and frameworks contained in this report can be easily accessed by managers within other public transit agencies. Finally, the creation of a "FlexBus Calculator" would further assist these managers assess whether implementing a FlexBus service in their own jurisdiction would be feasible. The calculator would be included on the website and accept input data specific to the public transit agency. The calculator would then output results indicating what routes would be most ideal for ride-hail integration and what type of savings could be expected.

Acknowledgements

We would like to thank the following individuals for their help and advice throughout this project: Nicole Berg, Dr. Andy Hoffman, and Dr. Margaret Wooldridge from the Graham Sustainability Institute, Connie Deford from The Dow Chemical Company, Michael Benham and Julia Roberts from the AAATA, and finally our faculty adviser Dr. Joe Grengs.

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