GOVERNMENT OF THE DISTRICT OF COLUMBIA
DEPARTMENT OF FOR-HIRE VEHICLES

REVIEW OF NEIGHBORHOOD RIDE SERVICE BY TAXICAB (NRS) PILOT PROGRAM

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1.0 Introduction

1.1 Overview

This report presents a study of the D.C. Neighborhood Ride Service by Taxicab (NRS) Pilot Program, a micro-transit-type taxicab van service operating from Fall 2016 to date, primarily in three wards (4, 7 and 8) with the support of a grant from the Department of For-Hire Vehicles (DFHV or Department).[1] In this document, we review the economics of NRS and provide an assessment of existing and potential service routes, including profitability. We find that city-center routes – particularly those focused on Union Station – are the most likely to be commercially-sustainable in the future.

1.2 Executive Summary

Taxicab van services differ from traditional taxicabs in that they carry multiple passengers at separate fares, and may be tailored to demand. Such a service may be called "micro-transit" in that it effectively provides an intermediate service between traditional taxicabs and small bus services and has similarities to both.

A number of cities around the world have undertaken taxicab shuttle trials similar to the NRS concept, including New York, Belfast, and Istanbul, amongst others[2]. Taxicab shuttles can include a range of service types, which are reflected by a number of alternatives in Washington D.C., in addition to the NRS pilot. The range of services suggesting that taxicab shuttles, in a variety of forms, can operate at a profit. Examples of other commercially-operated pooled vehicle-for-hire services include Uber Pool and Lyft Line.[3], and the now-defunct Bridj service, which had provided service in the District until its closure in early 2017[4].

This report assesses the effectiveness of a range of shuttle routes and service patterns[5], concluding that city-center taxicab shuttles operating to and from Union Station are likely to operate commercially without significant subvention in the long run, set out in section 7.3 below. Suburban routes in their current patterns are unlikely to operate for a profit and would require a moderate-to-large uptake in the number of passengers before being able to become profitable. That said, there are also social benefits that accrue from the shuttle service, as each provide an increase in the level of mobility and access of their users –above the commercial benefit realized by the operator.

This report concludes that NRS routes less likely to achieve break-even are those which appear complex and convoluted, and those which operate circuits or serve differing roads on the outward trip compared to the return trip. Further, routes shorter than three miles in each direction appear more likely to break even, with short city-center routes able to break even the quickest.[6]

During the pilot, all NRS routes operated at a loss of $8-15 per passenger per trip. This loss is partly associated with the lack of sufficient numbers of passengers, but is also associated with the relatively long distances of each route. Simpler and shorter routes are likely to prove effective in providing access to local facilities. In addition to the analysis of the pilot routes, three suburban lines and three city center lines have been assessed, including: Wisconsin Avenue, Rhode Island Avenue, and C Street. In each of these instances, a shorter route has been tested in preference to a longer one. While each of the three suburban routes would also require a per-passenger subsidy, the amount of this is significantly below those seen in the pilot: between $3.50 and $5.50.

This paper also considers the lessons to be learned from the NRS pilot and other pooled services such as Bridj and the TNC-operated services. Lessons include the need to be aware of, and avoid, over-estimation of demand, as may have been the case for Bridj; and account for potential passenger trade-offs between total journey time and cost. A further lesson appears to be the need to establish the perceived comparability of shuttle services with taxis at one end, and transit options at the other end of a transport 'hierarchy'. These issues are discussed in more detail in section 5, below.

The viability of potential future city-center routes were tested to include the impact of services that served a distributor function from a transit hub, in this case Union Station, in addition to servicing local residential populations. The three routes included Mass Ave, H and E Streets. None of the city center routes are likely to be commercially viable on the basis of residential traffic alone, which is significantly reduced in most city centers; but all three performed significantly better when serving a distribution function for arrivals and departures from Union station.

Of the three Union Station routes tested, both E and C Street routes are likely to operate at a profit. Public surveys of users also suggest a high level of satisfaction with the service provided on pilot routes, but may also indicate a lack of route knowledge in some user groups of routes and a lack of marketing. In the following sections we set out our analysis and calculation methods.

In light of the review in this report, we conclude that the following factors should be considered in developing future taxicab shuttle routes:

- Routes should generally be limited in length to three miles in each direction;[7]
- Wherever possible, shuttles should avoid circuitous routes and those that serve different streets in each direction;
- Some flexibility of fare should be reserved to operators, to allow for higher fares where necessary to support the viability of the service;
- Stops and termini should be recognizable and include street furniture (signs and poles);
- Each stop or terminus should provide customers with sufficient information on how to use the service;

- There should be a public information campaign to support the development of the service, particularly at the launch of a new route; and

- Taxicab shuttles should be considered for inclusion in the WMATA Smartrip payment system.

1.3 Terminology

A variety of terms have been used to describe for-hire services like NRS: taxibus, micro-transit, jitney, demand responsive bus transit (DRT), and van services, some of which are well-established and have existed for decades. Terminology may or may not reflect substantive differences in service. For example, taxicab shuttles are similar to DRT in that multiple passengers are carried at separate fares, while services remain flexible and tailored to demand. In addition to single service definitions, a collective term is sometimes applied: flexible transport/transit services (FTS), indicating that some elements of flexibility in booking and/or access points exist. Similarities exist between the original mode and the flexible version, for example: taxibus services display similar characteristics to taxicabs, both in terms of the vehicle licensing and vehicle type used, while paratransit services share some of the characteristics demonstrated by line-based buses, typically route choice and operational control.

The similarities between both taxicab and bus modes, and their flexible versions, have led to trials by both operators and traditional transit agencies under a plethora of names, as referenced above. While all such services have the common principles of multiple occupancy (which may or may not be achieved), shared ridership, and separate fares, many differences also exist including: rider eligibility, as in DRT aimed at human services and medically-focused services (e.g. DFHV's Transport DC) program); planning of shared transit (e.g. Bridj) with the added requirement to match routes (including taxicab shuttles); and defining routes on an ad hoc basis (e.g. the TNC services).

1.4 Methodology

The analysis uses a market model based on marginal operating production costs, observed trip number and standardized fares. The analysis also includes a simplified traffic model, based on observed use, which is applied to assess possible route development on the basis of current and historic use. The potential for services are also assessed in terms of route alternatives and potential pricing points, set out in more detail below.

An initial calculation of route profitability and loss is based on an assessment of the marginal costs and income per trip, which is used to provide a baseline analysis for a review of additional services, set out below.

2.0 Economic Viability

The current NRS taxicab shuttle pilot uses short wheelbase Ford Transit-sized van vehicles without accessibility modifications to carry up to eight passengers on a fixed route under a license issued by DFHV. Vehicle capital (purchase) costs are covered by a DFHV grant during the pilot, though all operational costs fall to the current operating company, Transco.

Table 1: Marginal operating cost elements / cost assumptions

Cost Element	Marginal value	Units	Estimated cost per service mile
Labor	$16.00	/ Hour	$2.00
Miles driven in service per Labor Hour	8	Miles (MPH)	
Fuel	$2.50	/ US Gallon	$0.14
Vehicle efficiencies	18	MPG	
DFHV passenger surcharge	$0.25	Per trip (charge through)	$0.00
Positioning and empty running	$2.50	Fuel cost only	$0.07
Proportion of live miles used in positioning	0.5		
TOTAL COST OF PRODUCTION / live mile			$2.21

On the basis of the above figures, we estimate that the NRS taxicab shuttle vehicle displays a marginal production cost of $2.21 per live service mile[8], including an allowance for fuel costs and labor.

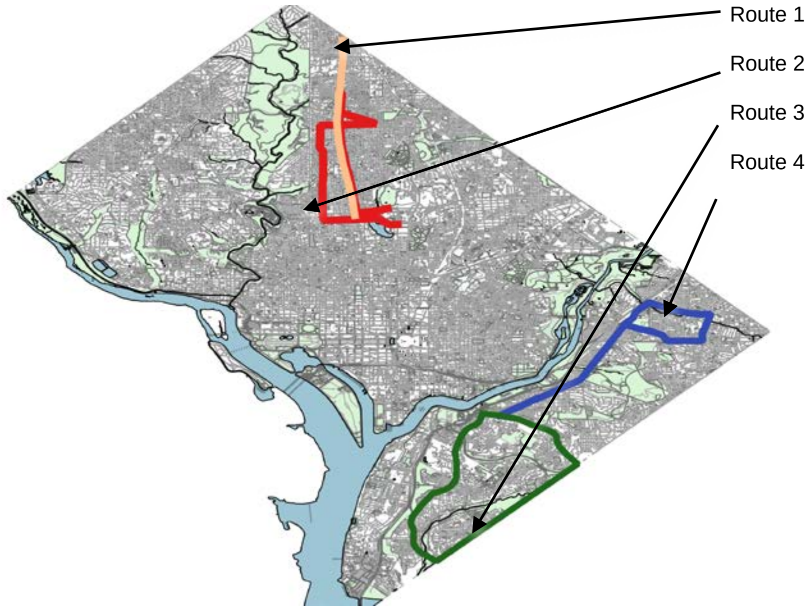
Additional costs, including vehicle purchase and maintenance, are not included in this initial figure as they are likely covered by the vehicle grant scheme, but are addressed in subsequent sections of this report.

2.1 NRS Pilot Service

Service under the pilot was established away from the downtown core, with the intention to provide access to communities with less frequent mainstream services. See map 1 below. The initial NRS routes are:

Route 1: Georgia Avenue - Linear Route, Ward 4
Route 2: Hospital Center - Circular route, Ward 4
Route 3: Circular route, Ward 8
Route 4: Mixed Linear / Circular, Ward 7

Routes are defined and do not allow for variation or diversion in normal circumstances. Two patterns exist: Linear Routes, which operate in both directions along the same street(s); and Circular Routes, which include a circuit using differing streets in each direction, see map 1.



Map 1: NRS shuttle routes (operating in outer wards)

2.1.1 Operating Pattern

Unlike an ordinary taxicab, taxicab shuttles operate along a defined route, typically following a headway pattern of operation. Vehicles may carry up to eight passengers, with each passenger paying a different fare, which can be up to $5, but is currently set at $3.25. An allowance is made for small groups, who currently pay the same rate as an individual. See below.

2.1.2 Public Response to the NRS Pilot

Based on survey responses from users of the NRS service, public opinion about the NRS pilot is very positive, though NRS remains a little-known transportation option. A survey with 86 valid responses has been undertaken, summarized, and tabulated in Appendix 2 of this document.

Home-based trips account for the largest proportion of NRS origins and destinations, with 43% of respondents starting their journey at home, and 45% completing their journey at home. These two data points effectively reflect outbound and return portions of similar trips. Shopping is the second largest origin (28%) and destination (33%), which may suggest that around 74% of all trips are made between home and shopping.

Metrorail stations are the third largest category, with 15% of origins and 10% of destinations. Other trip origins include Workplace - 10%, and Church and Doctor appointments (2% and 2%). Smaller percentages are shown as destinations and include school (2%) and “Other” (5%). See appendix 2.

User satisfaction rates were very high, with 93% “very satisfied” with the service they received and the routes made available. 95% of respondents found the price of the trip to be “very satisfactory”, though only 75% of users would be “very likely” to buy a multi-trip pass.

Survey results do not reflect potential new demand that may exist amongst members of the public not currently aware of the service.

2.2.0 Route Viability

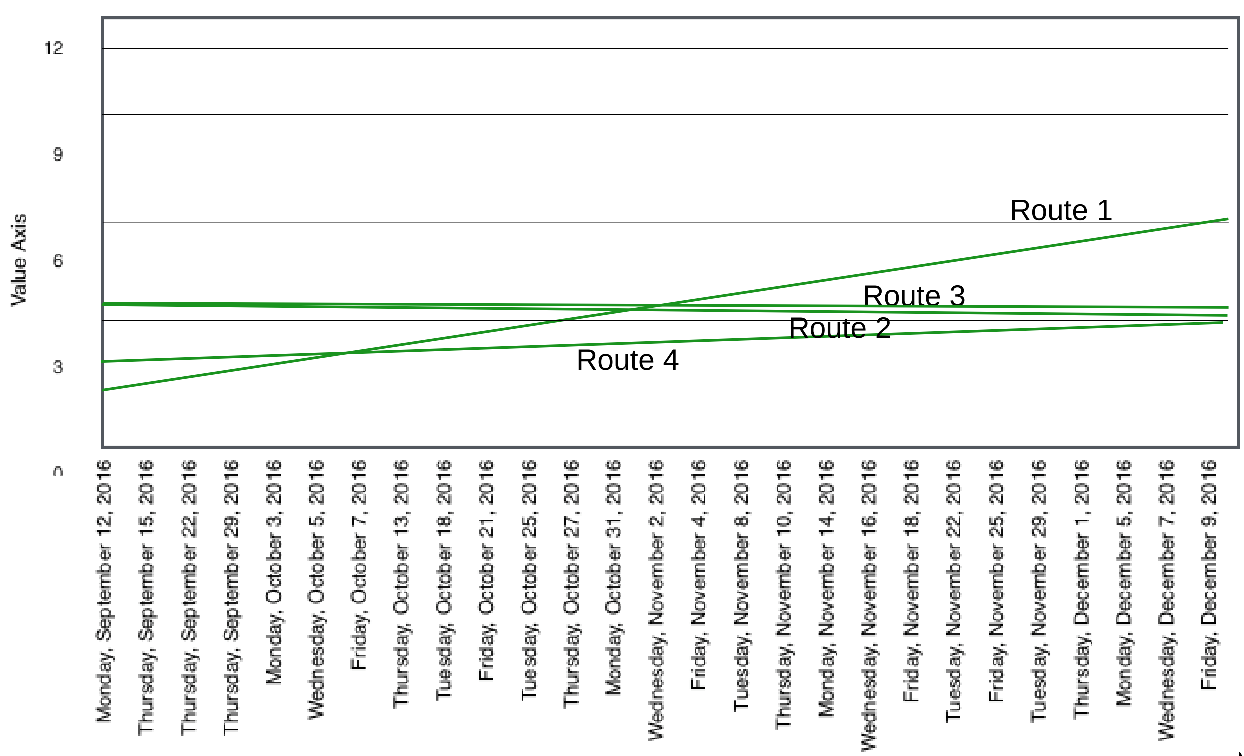
Each of the four pilot routes has been tested in terms of the original numbers of trips following three months, set out in table 2 below.

At the point of the initial analysis it appears that none of the four routes were operating commercially. In addition to the first-round cost analysis, an analysis of user trends was applied. See figure 1. This analysis suggests that, in their initial configuration, only one of the four nascent routes had the potential to become profitable[9].

Table 2: Initial Review – NRS shuttle route profitability

	Linear Miles per circuit (Return trip)	Mean Trip number / day operated	Average Loading	Revenue / day operated	Cost / day operated	Profit (Loss) / day operated
Route 1	7.6	3.81	1.08	$12.34	$68.60	-$56.26
Route 2	8.4	3.48	1.04	$10.87	$72.40	-$61.53
Route 3	8.9	3.5	1.04	$10.90	$84.19	-$73.29
Route 4	9.6	2.6	1.08	$8.47	$65.44	-$56.97

Figure 1: NRS route use trends - First 3 months of service



The initial analysis does not support the idea that no such route may be profitable, however. There is a clear indication that Route 1 has the potential for break even and potentially commercial operation.

2.3.0 Route characteristics

Route 1 has a number of characteristics that may support its viability, such as:

- It is a linear route with no parallel or circuitous deviation;
- It operates in high-density residential and commercial mixed neighborhoods; and
- It has a relatively short passenger mile carried.

3.0 Operating Reviews: Q2

In line with the methodology described above, a further route review was undertaken at the end of the second quarter's operation. This allows for a comparison of baseline and service trend. Tables 5 - 8 set out the current numbers of trips by route and profitability prior to modification.

3.1.0 Operating Review: Line 1

Table 5: Route 1 Q2 / Baseline cost analysis[10]

Cost Element	Q2 Value	Q1 (baseline) value
Marginal cost of production / live mile	$2.21	
Route distance	7.6	
Vehicle trips / day	6.43	
Passenger trips / day	9.57	
Average Loading	1.49	
Passenger Fare	$3.25	
Revenue / day operated	$31.11	$12.34
Marginal operating cost / day operated	$107.89	$68.60
Profit / Loss per day operated	-$76.79	-$56.26
Profit / Loss per passenger	-$8.02	

Route 1 displays the lowest per passenger costs of any of the four routes with a current cost level of $8.02 in subvention per passenger carried. It is also the busiest of the four routes operating an average of 7 trips per day[11] with an average loading of 1.49 passenger trips per vehicle trip (up from 1.09 at baseline).

The route does show the highest loss per day of the four routes reflecting the relatively high numbers of vehicle trips being made.

3.2.0 Operating Review: Line 2

Table 6: Route 2 Q2 / Baseline cost analysis

Cost Element	Q2 Value	Q1 (baseline) value
Marginal cost of production / live mile	$2.21	
Route distance	8.4	
Vehicle trips / day	5	
Passenger trips / day	6	
Average Loading	1.2	
Passenger Fare	$3.25	
Revenue / day operated	$19.50	$10.87
Marginal operating cost / day operated	$92.75	$72.40
Profit / Loss per day operated	-$73.25	-$61.53
Profit / Loss per passenger	-$12.21	

Route 2 also displays a higher number of passengers but a relatively poor passenger cost ratio rate compared to line 1. This may reflect the physical layout of the route, but also its relative paucity of service, discussed in subsequent sections. Both routes 3 and 4 are operated on a more time-limited basis, limiting both the potential for route development and demonstrating potential for a restricted service, discussed in more detail below.

3.3.0 Operating Review: Line 3

Table 7: Route 3 Q2 / Baseline cost analysis

Cost Element	Q2 Value	Q1 (baseline) value
Marginal cost of production / live mile	$2.21	
Route distance	8.9	
Vehicle trips / day	5	
Passenger trips / day	6.66666666666667	
Average Loading	1.33333333333333	

Cost Element	Q2 Value	Q1 (baseline) value
Passenger Fare	$3.25	
Revenue / day operated	$21.67	$10.90
Marginal operating cost / day operated	$98.27	$84.19
Profit / Loss per day operated	-$76.60	-$73.29
Profit / Loss per passenger	-$11.49	

3.4.0 Operating Review: Line 4

Table 8: Route 4 Q2 / Baseline cost analysis

Cost Element	Q2 Value	Q1 (baseline) value
Marginal cost of production / live mile	$2.21	
Route distance	9.6	
Vehicle trips / day	3.5	
Passenger trips / day	4	
Average Loading	1.14285714285714	
Passenger Fare	$3.25	
Revenue / day operated	$13.00	$8.47
Marginal operating cost / day operated	$74.20	$65.44
Profit / Loss per day operated	-$61.20	-$56.97
Profit / Loss per passenger	-$15.30	

4.0 Peer locations: Lessons and Issues

In addition to the cost analyses, a further review has been undertaken to take account of actual experiences in other locations.

Shared transit is not a new phenomenon (Mulley and Nelson, 2009), with documented examples of both ‘ad hoc’ (on-demand) and ‘line’ (planned and routed services, including DRT). Most U.S. services have developed along the principles of planned and routed line services, sometimes called ’Jitneys’, often operated without significant booking technologies, running along defined routes, often not departing an origin until the vehicle is full.

One of the key observations that may be taken from peer locations arises in respect of the various attempts to maximize vehicle occupancy. Most locations having sought to implement some form of trip planning. These include: booking requests - one of the key concepts behind Demand Responsive Transportation (DRT), various forms of route planning and route deviation, and timed departures based on optimal numbers of passengers, though this does not imply that a vehicle need be full.

DRT versions of shared transport can be traced in parallel to Jitneys, and tend to differ in terms of the company or agency providing or supporting the service. Many DRT routes having specific human service or medical transport pre-requisites. Other definitions include ‘Microtransit' being the commercial and publicly available version of DRT, often emerging as a result of improved booking and response times, referred to by Mulley and Nelson as the “Demand Responsiveness” of the service, see figure 2.

Figure 2: The Demand Responsiveness of Public Transport[12]

More recent versions of planned services have emerged, often referred to as ‘pooled services’, notably as a result of app booking. The range of planning information provided at point of use by the app contributes to greatly improved response times, much closer to instant or on-the-spot bookings expected of taxis. This in turn results in an almost instantaneous booking of line transport, blurring the distinction between on-demand and planned shared transport.

4.1 Pooled Services - TNCs

The entry of TNC companies like Lyft and Uber into the transportation market brought with it – and was largely focused on – the use of apps. These have continued to develop in the 6 or 7 years since TNCs have been active in the market, including in the development of planned shared transport, marketed as Lyft Line and Uber Pool by the two largest US TNCs.

The TNC version of shared transport, TNC pooled and TNC line services, are based on offering what might have been booked as a traditional individual ride for planned shared use. The TNC version of flexible transit leans toward the taxi-like service offered by their core products, and is offered as a lower cost version of both companies’ base product: UberX and Lyft. Passengers are given the option to book the pooled version of the same request, the onus then falling to the TNC to link that booking to other passengers with similar origins and destinations. The passenger receives a discount – typically about $1-2 per trip – set against an additional delay, estimated at around five minutes[13], while the TNC benefits from multiple fares for the same journey.

Little risk exists in terms of the use of TNC pooled services, either to the TNC company, nor to the passenger. The primary strength related to the speed of booking, planning and response enabled by the existing app. It is likely, however, that the benefit is not linked to the booking capabilities of the app alone, but also to the significant planning data. Pooled services are marketed and usually seen as a directly comparable and effective alternative to the x-class service in single occupancy, or at least comparable to a margin within the $2 saving that pooling may result in, to an extent that might not be possible in comparing taxi-shuttle services as a directly comparable alternative to a taxi. The same issues may arise in comparing Microtransit to bus equivalents, see next section.

4.2 Micro-bus/Micro-transit Services

In the same way that the TNC version of flexible transit may be seen as the extension of taxicab-like services to a shared use audience, so micro-transit might be seen as the extension of booking technologies to more traditional jitney and small bus lines. The U.S. start-up 'Bridj' was an example of a technology-focused jitney service operating in Washington DC, amongst a small number of other US cities, other example of which include 'Flipper', 'OpenDRT', and 'T2E Transport to Employment'. Bridj offered a bus-based area-to-area service within two primary areas of Washington, D.C.

Bridj vehicles were initially intended to carry up to 14 passengers that would be matched against routes defined by historic trip pattern algorithm. The vehicle size being defined against future demand estimations, while the route planning system would benefit future passengers. While the decline and ultimate demise of Bridj have been attributed to a number of issues including differences between potential investors – the actual decline might be best attributed to three primary factors:

- Lack of marketing to potential users;
- Over-reliance on an algorithm for route definition without sufficient data; and
- Economic failure, inability to meet costs from revenue.

Lack of knowledge is a fatal flaw in defining routes for these services, as it impairs marketing to potential users. In this instance, Bridj, and other new services have no meaningful method of competing with existing and powerful app companies such as Uber and Lyft. To define expectations alongside such apps would be to fundamentally misunderstand the market. More appropriate might be to define and operate a single or small number of short routes against which the market may be developed. These individual routes might then be heavily marketed and promoted to the potential audience within their corridors.

The second issue, directly related to the first, is the use of algorithms to define demand on a live basis. These allow the provision of services in the style of TNC operations, which fail because the micro transit operator both raises expectations and lessens the ability to serve all markets thus identified from a small fleet of larger vehicles. In fact, the application of an historic use algorithm to a new market fails in that precious little historic data is actually available, and the wide variations in routing that this may result in during early operations, further reduces the attractiveness of the service.

The third, and ultimately fatal, issue is the inability of the service to achieve a viable commercial model. The need or desire to come close to bus fares clearly pitches the product at a bus audience, but fails to establish the necessary income to cover cost. It is noted in the case of Washington DC operating subsidies alone cover 50% or more of transit costs, while capital costs are widely supported as well. Though TNCs have demonstrated that such operations may be viable, the TNC fare rarely falls to the level of a bus fare, while actual cost prices in initial operations may set fares above an attractive level to the user.

Neither Bridj, nor its European equivalents have managed to achieve mainstream operation, though a number of specialized services, such as T2E, appear to have achieved social and public goals. In most instances, demand appears to have been over-estimated, including in the case of Washington DC Bridj, where the actual level of demand experienced were a fraction of those initially predicted. In contrast, TNC pool services appear heavily used, with one blog entry suggesting that 60% of all uberX requests select the shared version of the service, with potentially multiple millions of such requests each month.

It is likely that these significant differences reflect the levels of knowledge and method of booking that apply to each. TNC pooled services are integrated as a direct alternative option to the traditional TNC service, sharing marketing and visibility with their mainstream equivalents, and thus being visible to the same size of audience.

In contrast, without the benefits of a pre-existing app audience, Microtransit starts with a much smaller potential audience and may have none. Even using the most optimistic example for Washington DC, that every intending taxi passenger had the direct choice between the classic and a shared taxi trip, this would still result in approximately 1/3rd of the audience of the TNC equivalent. As this is a highly unlikely scenario, Microtransit has a much smaller base on which develop, potentially being 1/100,000 the size of the TNC equivalent.

4.3 Market Transferability

The development of a shared vehicle option appears to contrast sharply between those locations and operators that have achieved runaway success, and those struggling to maintain the barest minimum service. But contrasting these two extremes may, in fact, be comparing two different routes to market and service types. To expect a new service to achieve the levels of ridership seen in TNC pooled services is likely unrealistic.

Nascent services, including the now defunct Bridj, and potential taxicab shuttle services are likely to be successful on the basis of a small audience single route (small number of routes) than a city-wide option. Critical to success include:

- Definition of location within the market (i.e., identification of the primary audience);
- Extent to which seen as a viable and/or cost effective equivalent to existing services; and
- Extent to which services match demand patterns, including the time and convenience costs of any transfers required.

Further success may be identified against a pattern of limited (single route) operation at commencement, and the marketing of routes to a defined local audience sufficient to ensuring demand growth on a sustainable level.

5.0 NRS Route Development and Analysis

In the preceding sections, we established baseline and Q2 cost measurements for the existing shuttle services. The comparison between baseline and Q2 operations suggests that potential for growth exists across some of the current routes. It also suggested that some modification of routes may be appropriate.

A structured approach was adopted to the assessment of routes, to include the assessment of new routes and the update of existing routes including:

- Amendment of Route 1 to include an extension at the southern extent of Georgia Avenue;

- Testing of four suburban routes; and

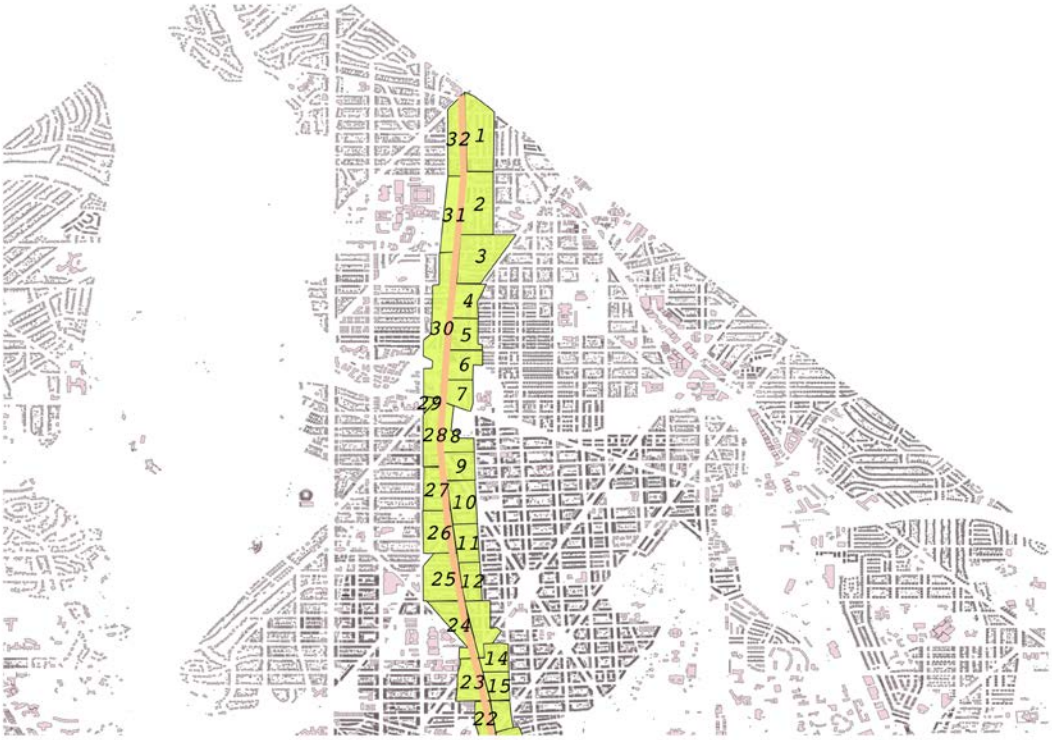
- Testing of four city center routes focused on travel to and from Union Station.

The approach adopted includes assessment of: Trip production, Trip Destination, Trip Purpose and Route Choice. The elements reflect a traditional approach to traffic and transportation modeling known as a ‘Four-stage Transport Model’ and are summarized below. Critical to this analysis is the extent to which services thus defined meet the demand patterns of the populations served.

5.1.1 Trip Production

Trip production relates to the numbers of trips that exist in any given location. A trip may be generated as a result of an individual leaving a residential address to access an activity, but may also arise as a result of transferring from another mode of transport at a given location, for example, a railway station, airport, or coach stop. Trips may also be produced in large numbers at high capacity events, such as football matches, at a specific time, e.g. when a match finishes; and on a smaller scale as the return portion of any outbound trip.

For the purpose of route assessment, a trip production factor is calculated on a mixed residential and commercial factor basis, where observed numbers of trips are associated to measured, illustrated in map 2.



Map 2: Production zones, route 1[14]

Each numbered segment shown in map 2 is defined as the area of census population zones[15] falling within a maximum distance of two blocks (approximately 600 feet) from the line of the route. The visible variation in area measured from the highway reflects the presence, or otherwise, of buildings within the area defined above. Using trip numbers from the first quarter of operation provides the calculation set out in table 3, below.

Line 1	Observed values, Q1
Corridor population	13,844
Days in service PA	234
Observed trips / day	6
Annual Trips	1404
Trips / head residential population	0.1014

Table 3: Route 1 trip production calculations, baseline

The calculation divides the observed numbers of trips by the residential population falling within the zone areas as defined. In the baseline calculation this results in 0.1 trips per person resident within the catchment area of route 1.

Where a consistent trip production rate is assumed, typically where a similar mix of housing, commercial or residential development is seen; additional trips may be assumed to accrue at the same level. This assumption allows for the development of new / amended route impact assessment, subject to validation and update as described in subsequent sections. The same assumption does not hold where a new route includes a large trip production point, which may include railway stations, football stadia etc.; each of which require individual consideration and a detailed assessment of trip production rates.

5.1.2 Trip Destination

Identification of destinations, also known as ‘trip ends’ provides a further element in route assessment. Trip destination may be specific, applies to one passenger alone (e.g. travel to a named building, shop, or Metro station), or generic (traveling to school, shopping, doctor’s appointment etc.), often associated with the trip purpose. Data pertaining to trip origin, destination and purpose are identified from travel surveys, including those undertaken by the DFHV in the period to spring 2017, are set out in detail below.

5.1.3 Trip Purpose

A further measure of trip type is derived in terms of trip purposes. In the traditional 4-stage model these include a range of work trips, education and other trip types, see table 4, which may also be further stratified by time of day and day of week.

Table 4: Typical 4-stage model trip purposes[16]

Purpose	Description
HBW	Home Based Work, a trip from home (residential address) to work
HBS	Home Based School, a trip from home to education
HBO	Home Based Other, a trip from home for any other purpose
NHW	Non-Home based work, a trip from an origin that is not a residential address to work
NHO	Non-Home based Other

Given the relatively small numbers of trips being made a smaller, more focused, range of trips is identified in the instance of the Taxicab shuttle service, discussed below.

5.1.4 Route Choice/Assignment

The fourth element relates to the assignment of trips to a route and a mode of transport. Trips may be assigned to existing forms of transport, or new alternatives. In this instance of the development of a new Taxicab shuttle route, this stage will assign trips to both existing and new choices available.

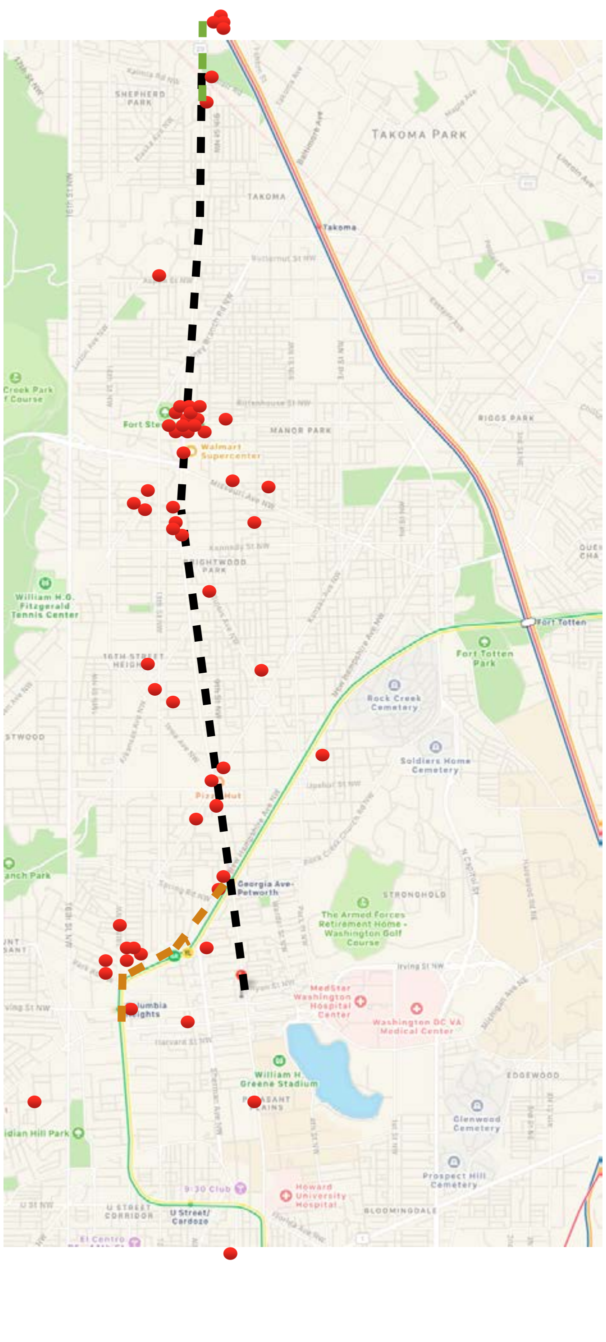
5.2.0 Initial Scenario Testing

Having identified key data points and approach to testing, the next step develops a series of scenarios for analysis. A scenario allows for the identification of the viability of a new route – or the impact of changes to an existing route – set out in subsequent sections.

5.2.1 Scenario 1: Route 1 Extension (Option One)

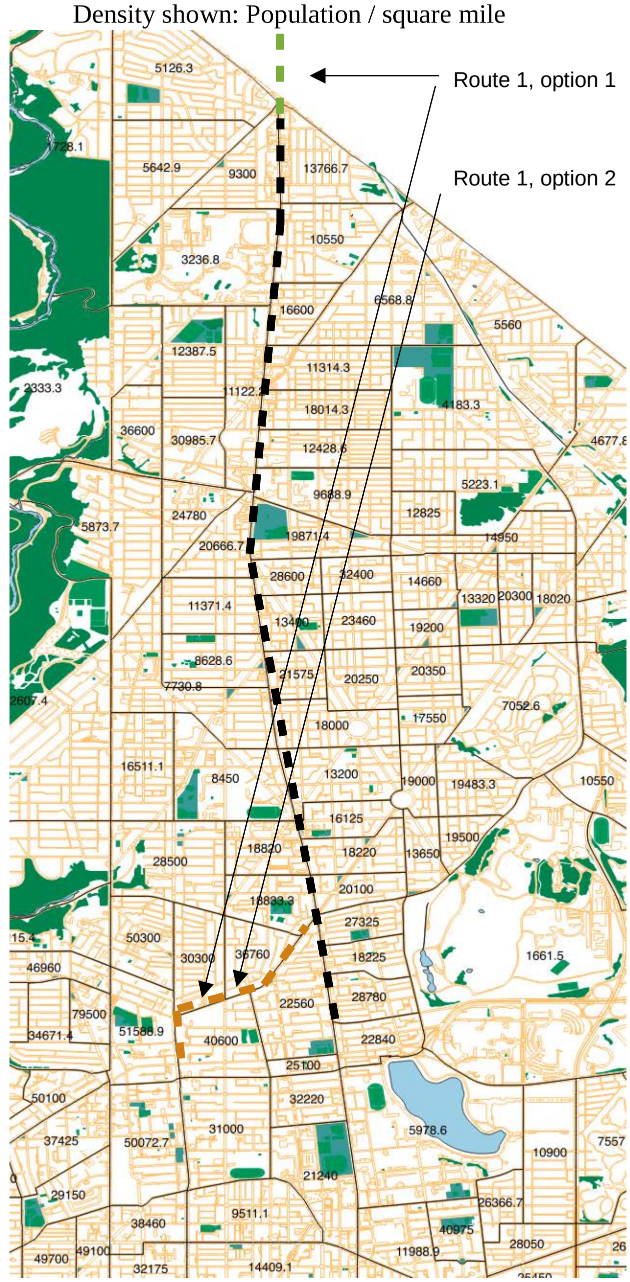
Route 1 runs along Georgia Avenue, and is currently the most popular of the Taxi shuttle routes. The route currently operates to the Irving Street intersection at its southern boundary, and north to the Shepherd Park area. Map 3 sets out the origins and destinations recorded for the use of the route in March 2017.

Map 3: Route 1 detail showing trip ends



Map 3a: Route 1 detail showing population density

Density shown: Population / square mile



A significant number of trips start and end at the Walmart supermarket located at the center point of the route. This said, additional trip ends are noted at the southern end of the route along Park Road NW as far as Columbia Heights, and to the north of the route toward Silver Spring.

By extending the route definition at both the northern and southern ends, a number of additional trips may occur as calculated in Table 5 below.

Table 5: Route 1 extension impact calculation, Option 1 (north and south extension)

Cost Element	Q2 Original route Values	Scenario route values
Marginal cost of production / live mile	$2.21	$2.21
Route distance (Miles round trip)	7.6	9.6
Vehicle trips / day	6.43	6.43
Passenger trips / day	9.57	10.86
Average Loading	1.49	1.69
Passenger Fare	$3.25	$3.25
Revenue / day operated	$31.11	$35.28
Marginal operating cost / day operated	$107.89	$136.29
Profit / Loss per day operated	-$76.79	-$101.00
Profit / Loss per passenger	-$8.02	-$9.30

Line 1	Observed values, Q2	Scenario values, Q2
Corridor population	13,844	15,702.831045977
r value per mile	2411.495215311	2,165.43489583333
Baseline frontage r value	18327.3636363636	20,788.18
Days in service PA	234	234
Trips / day	9.57	10.8565823263348
Annual Trips	2,239.71	2540.44026436235

The first scenario test identifies the impacts of extending route 1 both to the north and south of its existing route, illustrated by green and brown lines in Map 3, above. The extension at both ends of the route will result in an increased number of passengers, but also an additional cost arising from increased numbers of miles driven. The increase in costs exceeds the increase in revenue.

5.2.2 Scenario 2: Route 1 Extension (Option 2)

The second scenario tests the impact of extending services to the south of the existing route, and its diversion at Georgia Avenue / Petworth Metro to Columbia Heights Metro station illustrated by the brown line in Map 3.

By extending the route definition at its southern end, a number of additional trips may occur as calculated in Table 6 below.

Table 6: Route 1 extension impact calculation, Option 2 (southern extension)

Cost Element	Q2 Original route Values	Scenario route values
Marginal cost of production / live mile	$2.21	$2.21
Route distance (Miles round trip)	7.6	8
Vehicle trips / day	6.43	6.43
Passenger trips / day	9.57	10.80
Average Loading	1.49	1.68
Passenger Fare	$3.25	$3.25
Revenue / day operated	$31.11	$35.11
Marginal operating cost / day operated	$107.89	$113.57
Profit / Loss per day operated	-$76.79	-$78.46
Profit / Loss per passenger	-$8.02	-$7.26

Line 1	Observed values, Q2	Scenario values, Q2
Corridor population	13,844	15,625.6692091999
r value per mile	2411.495215311	2,585.75304878049
Baseline frontage r value	18327.3636363636	20,686.02
Days in service PA	234	234
Trips / day	9.57	10.803234377104
Annual Trips	2,239.71	2527.95684424233

By extending the route at its southern extent including diversion to Columbia Heights station results in a higher level of use and a lower level of passenger subsidy. The extension southbound produces a greater level of income than its additional cost, has a positive Net Present Value (NPV) of 1:1.1, suggesting that every additional $1 invested produces a net income of $1.10, illustrated in Table 7.

Table 7: Cost-Benefit NPV calculations - Route 1

	Baseline	Option 1: North and South extensions	Option 2: Southern extension only
Subsidy cost / trip	$8.02	$9.30	$7.26
Proportion of baseline	1	0.86	1.10
NPV	1:1	1:0.86	1:1.1

5.3.0 Route Viability and Break-even Points

In the initial analysis it was demonstrated that none of the current Taxi shuttle routes operated at break even. In this section we test the impacts of changes to fares and the numbers of passengers that would be required for a route to break even.

5.3.1 Adjustment of Fare

Route 1 option 2 provided the most positive NPV of the originally defined routes, suggesting that income would increase with extension over and above any additional cost. The route cost and income calculations are summarized in table 8, below.

Table 8: Break-even point (fares only)

Cost Element	Q2 Original route Values	Option 2 route values	Break even point by fares, option 2
Marginal cost of production / live mile	$2.21	$2.21	$2.21
Route distance (Miles round trip)	7.6	8	8.0
Vehicle trips / day	6.43	6.43	6.4
Passenger trips / day	9.57	10.80	10.8
Average Loading	1.49	1.68	1.68
Passenger Fare	$3.25	$3.25	$10.52
Revenue / day operated	$31.11	$35.11	$113.65
Marginal operating cost / day operated	$107.89	$113.57	$113.57
Profit / Loss per day operated	-$76.79	-$78.46	$0.08
Profit / Loss per passenger	-$8.02	-$7.26	$0.01

Table 8 also demonstrates that – all other factors remaining the same – a fare level of $10.52 is required for the service to break even. The high level of fare at which the service breaks even may partially reflect the length of the route which may suggest that a modification to reduce the length may be appropriate, but this is countered, in the case of the Georgia Avenue route by the presence of demand and trip ends at both ends of the route, limiting the potential for a significantly shorter route. The concept of shorter versus longer routes is discussed in more detail in sections 5.1 and 5.3, below.

While it is logical that a higher fare is appropriate to offset the costs of production, the calculated fare level of $10.51 is likely to be problematic, not least that a significantly increased fare will have the impact of reducing passenger numbers and eroding the bas upon which the service relies. The main alternative to increasing fare levels is to seek to increase passenger numbers. Thus the current average loading of 1.68 passengers per vehicle trip could be increased to a sustainable level, see table 9, below.

Table 9: Break-even point (Passenger numbers only)

Cost Element	Q2 Original route Values	Option 2 route values	Break even point by fares, option 2
Marginal cost of production / live mile	$2.21	$2.21	$2.21
Route distance (Miles round trip)	7.6	8	8.0
Vehicle trips / day	6.43	6.43	6.4
Passenger trips / day	9.57	10.80	35.4
Average Loading	1.49	1.68	5.50
Passenger Fare	$3.25	$3.25	$3.25
Revenue / day operated	$31.11	$35.11	$114.91
Marginal operating cost / day operated	$107.89	$113.57	$113.57
Profit / Loss per day operated	-$76.79	-$78.46	$1.34
Profit / Loss per passenger	-$8.02	-$7.26	$0.04

A break-even point is noted where an average loading of 5.5 passengers per vehicle is achieved, where the current fare level remains unchanged at $3.25. To achieve a mean level of 5.5 passengers it is likely that many services would actually operate full, at the vehicle passenger capacity of eight passengers.

While it can be noted that in instances where Jitney services have proven successful, such as the West Belfast Black Taxis and the Soweto taxibus, vehicles operate full at most times, it is unlikely that a nascent service such as NRS will achieve full capacity operations in its initial stages. Operating parameters should therefore be set at a level that implies some growth but also some modification of taxi fares.

Using the maximum level currently permitted of $5 per passenger trip, it is possible to establish the numbers of passengers required to break even. See Table 10 below.

Table 10: Break-even point (Fare and passenger numbers)

Cost Element	Q2 Original route Values	Option 2 route values	Break even point by fares, option 2
Marginal cost of production / live mile	$2.21	$2.21	$2.21
Route distance (Miles round trip)	7.6	8	8.0
Vehicle trips / day	6.43	6.43	6.4

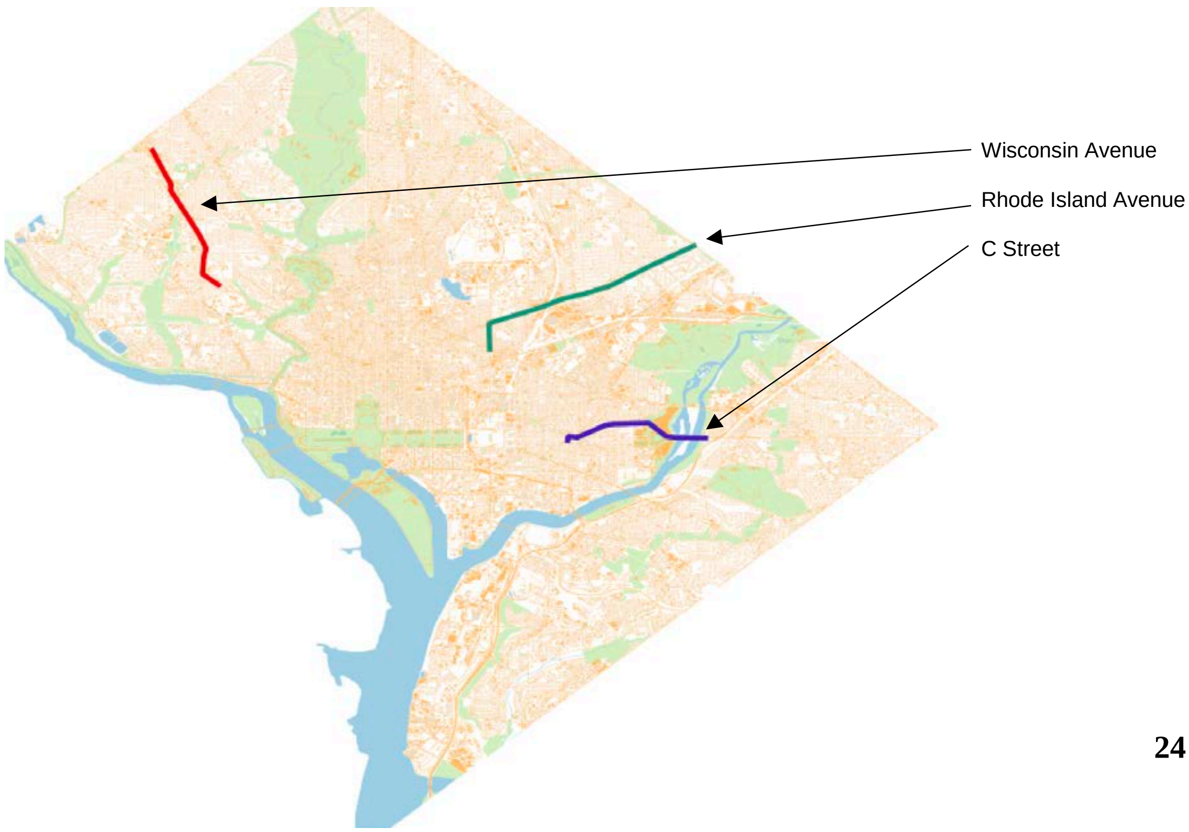
Cost Element	Q2 Original route Values	Option 2 route values	Break even point by fares, option 2
Passenger trips / day	9.57	10.80	22.8
Average Loading	1.49	1.68	3.55
Passenger Fare	$3.25	$3.25	$5
Revenue / day operated	$31.11	$35.11	$114.11
Marginal operating cost / day operated	$107.89	$113.57	$113.57
Profit / Loss per day operated	-$76.79	-$78.46	$0.54
Profit / Loss per passenger	-$8.02	-$7.26	$0.02

Where a fare of $5 per passenger trip was adopted, break-even would be achieved with an average passenger loading of 3.55 passengers. The use of a passenger loading requirement of four passengers or less also allows for future flexibility in vehicle choice and would, in theory, allow for the use of traditional taxicab vehicles if vans are not available.

6.0 Development of New Routes

This section considers the development of three additional routes not directly serving the downtown core. The routes selected for testing reflect similar characteristics as the original Taxi shuttle services, being provided in areas with limited taxi or transit services, and with a similar demographic mix, see map 4. Two differing route types have been tested, a series of new routes developed for communities with limited transit options outside the city center (Map 4), see section 6.1; and a number of central city options focused on Union Station. See section 5.3.

Map 4: Proposed new NRS routes for testing - outside city center



6.1 New Route Testing: Services Outside City Center

In the initial development of the NRS pilot, taxicab shuttle services were defined as being away from the city center. This included the provision of services focused on defined wards (Wards 4, 7 and 8). The limitation of a ward boundary does not fully account for actual trip patterns, trips being made by purpose and not associated with a political or ward boundary. The same issue may also occur for trips that cross the District boundary, for example for trips originating in DC and destined for Maryland. The second series of tests assessed the opportunity for new routes operating across the city, regardless of ward, but defined to avoid the city center

Map 4 illustrates three new routes tested in this section. The routes share similar characteristics to the original taxicab shuttle service definitions, but have been based on a linear pattern alone, reducing potential for confusion amongst passengers. The results of individual route analysis are set out below

6.1.1 Wisconsin Avenue

The Wisconsin avenue route runs along Wisconsin Avenue from Military Road in Friendship Heights, through Tenleytown and terminates at the junction with Massachusetts Avenue. Primary results from this route are set out in table 11, below.

Table 11: NRS shuttle route development, Wisconsin Avenue

Cost Element	Baseline values, route 1	Scenario route values	Break even point by loading @ $5	Break even point by loading	Break even point by fare
Marginal cost of production / live mile	$2.21	$2.21	$2.21	$2.21	$2.21
Route distance (Miles round trip)	7.6	4.8	4.8	4.8	4.8
Vehicle trips / day	6.43	3.16	3.2	3.2	3.2
Passenger trips / day	9.57	4.71	7.0	10.4	4.7
Average Loading	1.49	1.49	2.20	3.30	1.49
Passenger Fare	$3.25	$3.25	$5	3.25	7.2
Revenue / day operated	$31.11	$15.30	$34.77	$33.91	$33.89
Marginal operating cost / day operated	$107.89	$33.51	$33.51	$33.51	$33.51
Profit / Loss per day operated	-$76.79	-$18.21	$1.26	$0.40	$0.38
Profit / Loss per passenger	-$8.02	-$3.87	$0.18	$0.04	$0.08

Wisconsin Avenue Test	Baseline values, route 1	Scenario values, Q2
Corridor population	13,844	6,807.91460657437
r value per mile	2411.495215311	1,877.63541666667
Baseline frontage r value	18327.3636363636	9,012.65

Wisconsin Avenue Test	Baseline values, route 1	Scenario values, Q2
Days in service PA	234	234
Trips / day	9.57	4.70683822430019
Annual Trips	2,239.71	1101.40014448624

Table 11 illustrates the comparative costs and benefits that may arise from the development of a route along Wisconsin Avenue. Baseline values are taken from route 1, described in preceding sections, with an assumed demand pattern based on population density and road frontage.

The Wisconsin Avenue route demonstrates significantly improved levels of passenger use, partly resulting from the relative densities of the route, and partly as a result of maintaining a shorter route distance. The finding that a shorter route may prove more effective is also considered in relation to Union Station routes, discussed in more detail in section 6.3.

6.1.2 Rhode Island Avenue

The Rhode Island Avenue route runs from the intersection with Monroe Street NE to North Capitol. The same calculation is undertaken as per Wisconsin Ave, as set out in Table 12.

Table 12: Taxi shuttle route development, Rhode Island Avenue

Cost Element	Baseline values, route 1	Scenario route values	Break even point by loading @ $5	Break even point by loading	Break even point by fare
Marginal cost of production / live mile	$2.21	$2.21	$2.21	$2.21	$2.21
Route distance (Miles round trip)	7.6	5.8	5.8	5.8	5.8
Vehicle trips / day	6.43	3.35	3.3	3.3	3.3
Passenger trips / day	9.57	4.98	8.7	13.4	5.0
Average Loading	1.49	1.49	2.60	4.00	1.49
Passenger Fare	$3.25	$3.25	$5	3.25	8.61
Revenue / day operated	$31.11	$16.20	$43.51	$43.51	$42.91
Marginal operating cost / day operated	$107.89	$42.87	$42.87	$42.87	$42.87
Profit / Loss per day operated	-$76.79	-$26.67	$0.64	$0.64	$0.04
Profit / Loss per passenger	-$8.02	-$5.35	$0.07	$0.05	$0.01

Wisconsin Avenue Test	Baseline values, route 1	Scenario values, Q2
Corridor population	13,844	7,208.08399794131
r value per mile	2411.495215311	1,645.24375743163
Baseline frontage r value	18327.3636363636	9,542.41

Wisconsin Avenue Test	Baseline values, route 1	Scenario values, Q2
Days in service PA	234	234
Trips / day	9.57	4.98350629320662
Annual Trips	2,239.71	1166.14047261035

The Rhode Island route still performs better than the original Route 1 baseline, but is less effective than the Wisconsin Avenue route, set out directly above.

6.1.3 C Street

The C Street route runs north east from Lincoln Park, joining C Street to RFK Stadium and crossing the Anacostia River to include residential areas in the River Terrace district. The same calculations are undertaken as in the previous two route assessments, as summarized in Table 13.

Table 13: Taxicab shuttle route development – C Street

Cost Element	Baseline values, route 1	Scenario route values	Break even point by loading @ $5	Break even point by loading	Break even point by fare
Marginal cost of production / live mile	$2.21	$2.21	$2.21	$2.21	$2.21
Route distance (Miles round trip)	7.6	4.6	4.6	4.6	4.6
Vehicle trips / day	6.43	1.44	1.4	1.4	1.4
Passenger trips / day	9.57	2.14	3.0	4.6	2.1
Average Loading	1.49	1.49	2.10	3.20	1.49
Passenger Fare	$3.25	$3.25	$5	3.25	6.9
Revenue / day operated	$31.11	$6.95	$15.09	$14.95	$14.76
Marginal operating cost / day operated	$107.89	$14.60	$14.60	$14.60	$14.60
Profit / Loss per day operated	-$76.79	-$7.65	$0.49	$0.35	$0.17
Profit / Loss per passenger	-$8.02	-$3.57	$0.16	$0.08	$0.08

Wisconsin Avenue Test	Baseline values, route 1	Scenario values, Q2
Corridor population	13,844	3,094.99404915823
r value per mile	2411.495215311	890.718336483932
Baseline frontage r value	18327.3636363636	4,097.30
Days in service PA	234	234
Trips / day	9.57	2.1398089042556
Annual Trips	2,239.71	500.715283595809

The C Street route continues to perform well which may, in part, reflect the short distances of the route. It should also be noted that the route includes a major stadium, which will require trip planning and coordination at the time of games and large crowd use. This is discussed in subsequent sections.

6.2 New Route Analysis

In the preceding section, we analyzed three potential routes on the basis of similar attractions to those seen in existing NRS service. The routes all attracted trips from local residential populations on a regular basis. It is noted that one of the routes – C Street – also passes RFK Stadium, which, in addition to normal traffic levels, is likely to result in occasional high peak levels of demand, typically for each game start and end. These are not included in this test as they are likely to result in a justification for service based on infrequent events, but is further developed in section 5.3, which addresses peaks of demand at Union Station.

Table 14 illustrates the financial costs and benefits of each route, and further addresses the breakeven points in normal operating circumstances, for each.

Table 14: NRS shuttle service profitability and break-even point

Route	Base profit / loss per passenger carried @ $3.25	Fare required to break even, current demand	Loading required to break even @ $3.25 (pax / veh)	Loading required to break even, with fare at $5 (pax/veh)
Wisconsin Avenue	-$3.87	$7.20	3.30	2.20
Rhode Island Avenue	-$5.35	$8.61	4.00	2.60
C Street	-$3.57	$6.90	3.20	2.10

On the basis of the modeled demand it is possible to suggest the levels of income, cost and break even points for each of the routes tested. Using the same patterns of demand, based on residential population, the Rhode Island route is likely to have the highest cost to the operator, suggesting a $5.35 loss per passenger carried. The C-Street route performed the best suggesting a $3.57 loss per passenger carried. C-Street also benefits from the presence of a large occasional demand center at the RFK stadium, discussed in more detail in subsequent sections.

Table 14 also demonstrates the levels of demand required to break even at the current fare of $3.25, and the original $5 fare. The last column in Table 14 illustrates the calculated numbers of passengers required, on average, in each vehicle at a $5 fare. The C Street route requires 2.1 passengers per vehicle, Wisconsin Avenue requires 2.2 passengers, and Rhode Island Avenue requires 2.6 passengers. The concept of transit diversion and large event demand may also be considered a factor, as addressed below.

6.3 Union Station Route Analysis

In the preceding sections, we considered the development of the NRS shuttle on the basis of both a ward focus (the existing pilot routes), and services in suburban communities (section 5.1). In this section, we assess the potential for future taxicab shuttle services focused on city-center trips originating or destined for Washington's Union Station.
The focus on a large center of production and demand, such as a station, airport or event venue, requires a calculation in addition to those set out above, namely the numbers of trips that are generated at the venue itself. In the instance of Union Station, it is observed that a large number of trips originate from arriving trains as passengers seek to travel to their final destination, sometimes called trip distribution, and an equivalent (and generally equal) number of trips returning to the station for a return commute.

In this instance, we consider trip generation to include: detraining passengers arriving at Union Station and requiring transport to locations within the District, local residential populations, local workers, entertainment, and VFR passengers. The actual number of trips produced differs from the preceding route analysis insofar as it includes rail-based productions and attractions.

6.3.1 Rail-based Trip Production

Union Station is a terminus for five commuter rail lines (VRE and MARC), as well as being the second busiest railway station in the U.S. for Amtrak passengers. The station is also a major transfer point to the WMATA Metrorail system. Commuter trains tend to be tidal (operating at different frequencies according to time of day), and some do not operate a weekend service.

Table 15 illustrates the number of rail based arrivals at Washington Union station on a typical weekday. On a given day, about 64,000 trips originate at the station and are distributed to their final destination by a range of further modes, including transfers from one railway mode to another (typically heavy rail to Metro rail in the morning peak and its reverse in the evening peak).

Table 15: Rail arrivals at Union Station on weekdays[17]

Ral system	Alightings
AMTRAK	6,810
MARC Brunswick	3,624
MARC Camden	2,271
MARC Penn	13,023
VRE All lines	9,500
Metrorail	29,000
TOTAL	64,228

The Union Station arrival count (64,288 passengers) excludes any additional transport users who live locally in proximity to Union Station, and those arriving by others forms of transport and transferring at Union Station. Given the significance of the station as a transit transfer point, it is a potential center of demand for future NRS shuttle routes.

DDOT reports an additional 4,018 daily commuter bus alighting passengers[18] (2014) and an estimated 100,000 Metrobus riders per workweek per corridor that serve Union Station, though the latter figure is not accurate in terms of the number of users using Metrobus to access Union Station. WMATA reports also indicate 1,398 passengers alighting daily from the DC Streetcar.

Three separate corridor studies address actual numbers of trips made from Union Station using bus services[19], used in conjunction with Metrobus corridor analysis from 2016[20] can be used to narrow this figure down as illustrated in table 16.

Table 16: Bus ridership, bus lines serving Union Station[21]

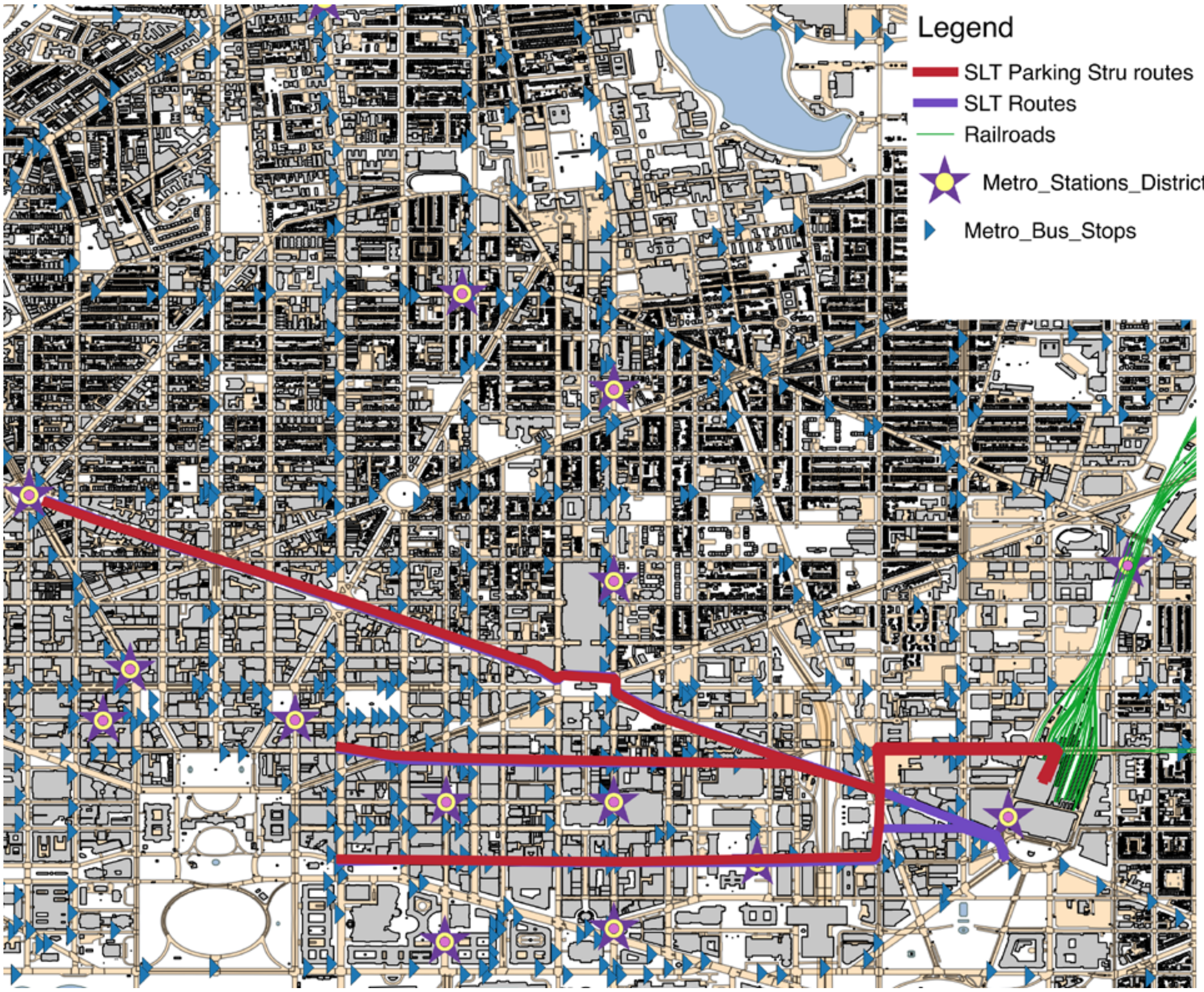
Line	Weekday ridership (route)	Union Station Alighting	Effective Alighting number used	Percentage @ Union Station stops*
80	7,758	401 (Southbound) 410 (Northbound)	811	10%
96 and 97	4,315	831 (Westbound), 706 (Eastbound)	1,537	36%
D1	377	N/A	87	23%
D3	575	N/A	132	23%
D6	4,423	N/A	1,019	23%
D8	3,906	N/A	900	23%
X2	12,439	N/A	2,866	23%
TOTAL			7,352	

Residential trips are also included, based on the production matrices developed in preceding analysis, and discussed in relation to three routes, set out below.

6.3.2 Union Station Route Development

Washington's Union Station is located to the east of most government offices and central D.C. tourist attractions, resulting in a significant distribution of passengers to locations to its west. The design of the station limits movements on roadways including a series of one-way and restricted-turning limits.

The analysis tested three routes radiating from Union Station with two potential starting points: the first physically located at the front of the station using an existing traffic lane currently reserved for tour buses; and the second including trips originating in the station's Parking Structure. See Map 5.



Map 5 Union Station routes

The three routes are:

1. Operating West from Union station along E Street, terminating at 14th Street NW / Pershing Park corner;

2. Operating West from Union station along H Street, terminating at 14th Street NW / Hilton Garden Inn; and

3. Operating North West from Union station along Mass Ave, terminating at Dupont Circle.

6.3.3 Taxicab Shuttle Trip Demand: Union Station routes

Trip demand is based on the summation of residential and transit originating demand, requiring two separate calculations. Residential demand is calculated on the same basis as described in preceding sections, and uses a trip production by neighborhood density measurement.

Transit-based demand is derived using a modal split calculation by arriving mode of transit. See Table 17. Some trip transfers were unusual or unlikely and have been excluded; for example, it is unlikely that a taxicab passenger would transfer from one taxicab to another, or taxicab shuttles and taxicabs, though neither of these scenarios is impossible. Transfers from rail to personal vehicles was also considered a very small proportion of trips. Where trip transfers were unlikely, or occurred at less than 0.1% in measured observation of all trips, it was excluded.

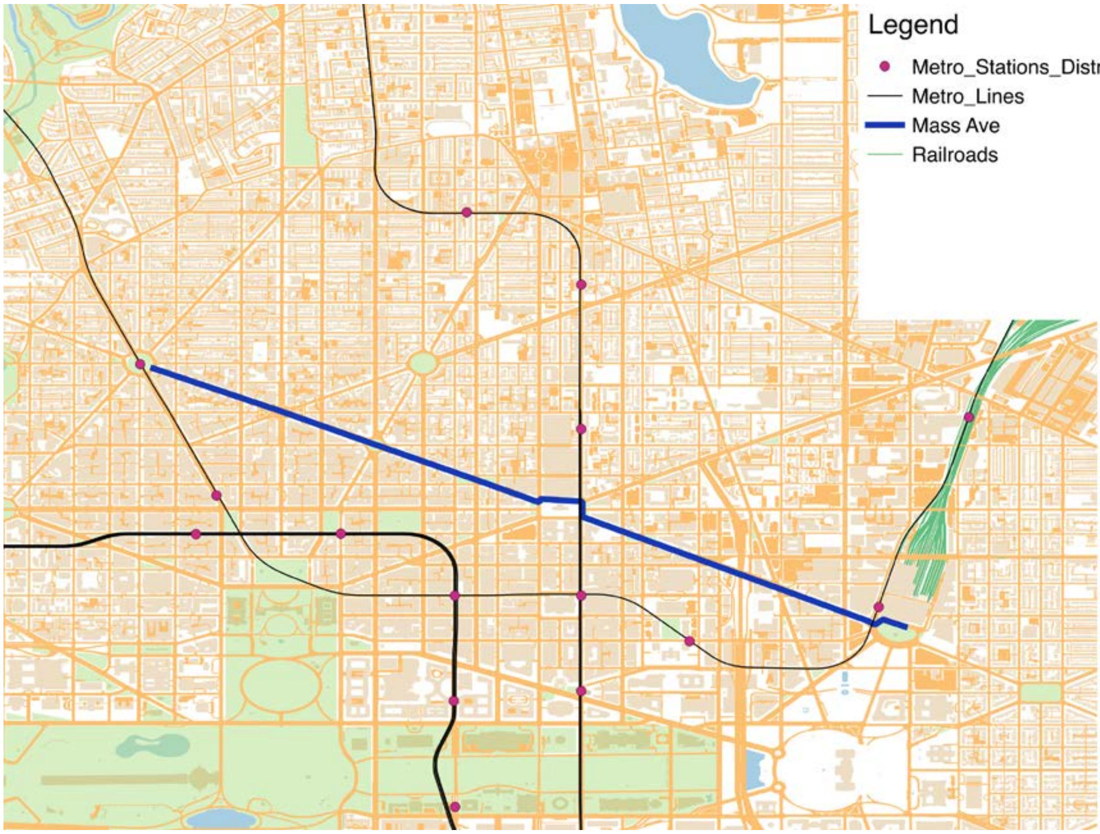
Table 17: Modal split by originating mode

\ Onward Mode Trip Origin \	% of total trip productions	Bicycle	Walk	Transit (Rail Metro / Bus)	Taxi	Taxi shuttle	Taxi shuttle x total trip pdns
Rail	82.3%	1.0%	5.7%	88.3%	3.0%	2.0%	1.647%
Metrobus	9.4%	1.0%	5.7%	90.3%	1.0%	2.0%	0.188%
Other Bus	5.2%	1.0%	5.7%	88.3%	2.0%	2.0%	0.103%
Streetcar	1.8%	2.7%	25.0%	69.0%	1.3%	2.0%	0.036%
Taxicab	1.3%	1.0%	2.0%	97.0%	0.0%	0.0%	0.000%
	100.0%						2.0%

Where a total of 2% of all trips transfer to taxicab shuttle: 1.65% originate from rail and 0.188% from Metrobus, etc. This allows for a calculation of total trip numbers by route, using WMATA trip counts to give a total number of transit-originating trips.

6.3.4 Massachusetts Avenue

A detailed analysis was undertaken for three routes originating from Union Station. The first relates to the operation of taxicab shuttle services along Massachusetts Avenue. See Map 6.



Map 6: Massachusetts Avenue taxicab shuttle route

The combination of transit originating trips and residential originating trips is set out, based on Massachusetts Avenue, in Table 18, below.

Table 18: Taxicab shuttle route development, Massachusetts Avenue

Cost Element	Baseline values, route 1	Scenario route values	Break even point by loading @ $5	Break even point by loading	Break even point by fare
Marginal cost of production / live mile	$2.21	$2.90	$2.90	$2.90	$2.90
Route distance (Miles round trip)	7.6	5.2	5.2	5.2	5.2
Vehicle trips / day	6.43	10.42	10.4	10.4	10.4
Passenger trips / day	9.57	41.69	32.3	48.5	41.7
Average Loading	1.49	4.00	3.10	4.65	4.00
Passenger Fare	$3.25	$3.25	$5	3.25	3.8
Revenue / day operated	$31.11	$135.48	$161.54	$157.50	$158.41
Marginal operating cost / day operated	$107.89	$157.16	$157.16	$157.16	$157.16
Profit / Loss per day operated	-$76.79	-$21.68	$4.38	$0.34	$1.25

Cost Element	Baseline values, route 1	Scenario route values	Break even point by loading @ $5	Break even point by loading	Break even point by fare
Profit / Loss per passenger	-$8.02	-$0.52	$0.14	$0.01	$0.03

Mass Ave Test	Baseline values, route 1	Scenario values
Corridor population	13,844	12,565.1531093596
r value per mile	2411.495215311	3,198.91608391608
Baseline frontage r value	18327.3636363636	16,634.36
Days in service PA	234	234
Trips / day residential	9.57	8.68726274742118
Trips / day transit		33
Annual Trips	2,239.71	9754.81948289656

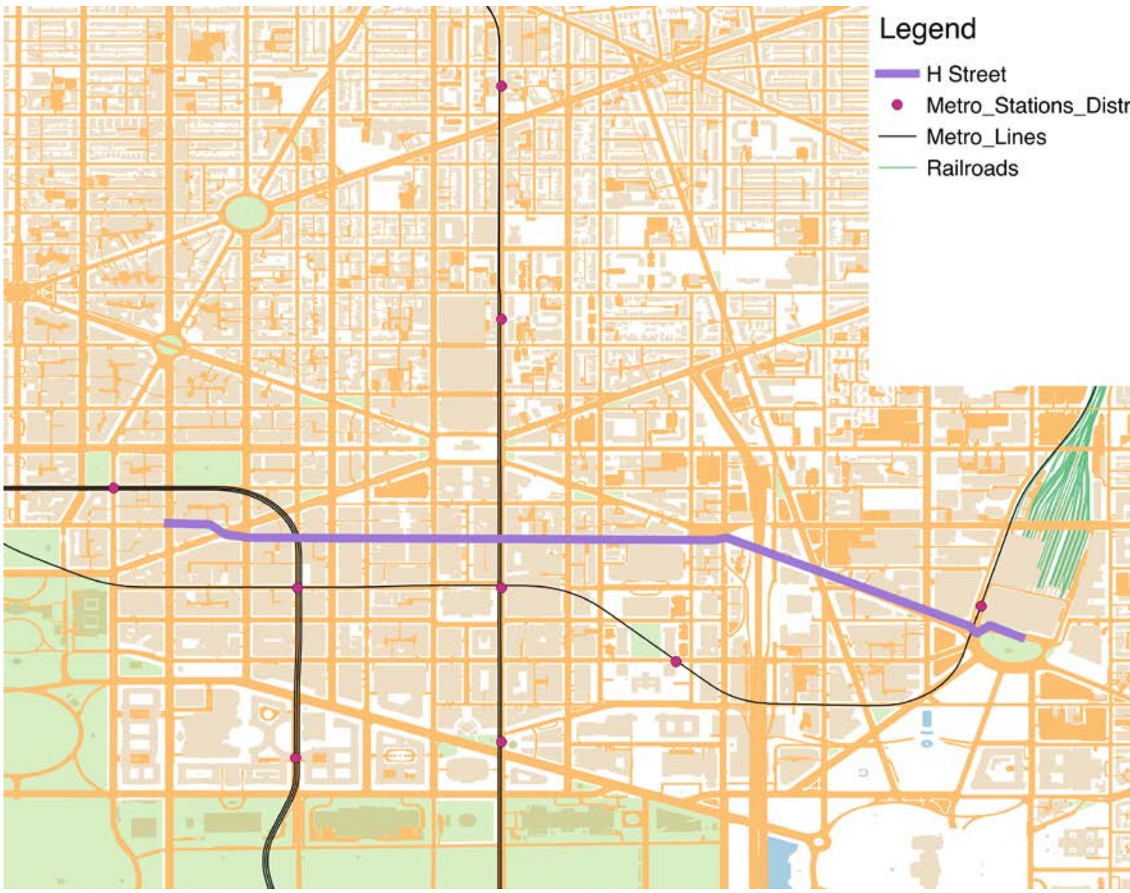
On the basis of residential demand alone, the Massachusetts Avenue route results in 8.6 trips per day which would not justify the development of the route on the basis of residential population alone. The addition of trips transferring from transit produce a significantly improved cost to benefit ratio, with the service incurring only a small cost per passenger ($0.26¢) if a fare of $3.25 were charged.

It should be noted that a higher route mile production cost of $2.90 per mile – rather than $2.21 in suburban trips – is applied to reflect increased time costs in the city center resulting from slower or more congested traffic patterns. The loading rate of four passengers per vehicle is developed in relation to a large weighting of passengers loading at Union Station during the morning peak hour. It is also reasonable to suggest that the service operating hours be harmonized to Union Station peak hours in both directions. For this reason, services would be provided from 6:30 to 8:30 a.m. based on taxicab shuttle departures from Union Station, and from 5:30 to 7:30 p.m. based on arrival times at the station.

Break-even is achieved where the fare is increased to $3.80, or where 4.65 passengers are carried per vehicle.

6.3.5 H Street

The H Street route runs northwest along Massachusetts Avenue, turning due west on H Street, to a terminus at 14th Street N.W./Hilton Garden Inn. See Map 7.



Map 7: H Street Taxicab shuttle route

The combination of transit-originating trips and residential-originating trips for the H Street route is illustrated in Table 19, below.

Table 19: Taxicab shuttle route development: H Street

Cost Element	Baseline values, route 1	Scenario route values	Break even point by loading	Break even point by fare
Marginal cost of production / live mile	$2.21	$2.90	$2.90	$2.90
Route distance (Miles round trip)	7.6	3	3.0	3.0
Vehicle trips / day	6.43	13.02	13.0	13.0
Passenger trips / day	9.57	52.07	36.4	52.1

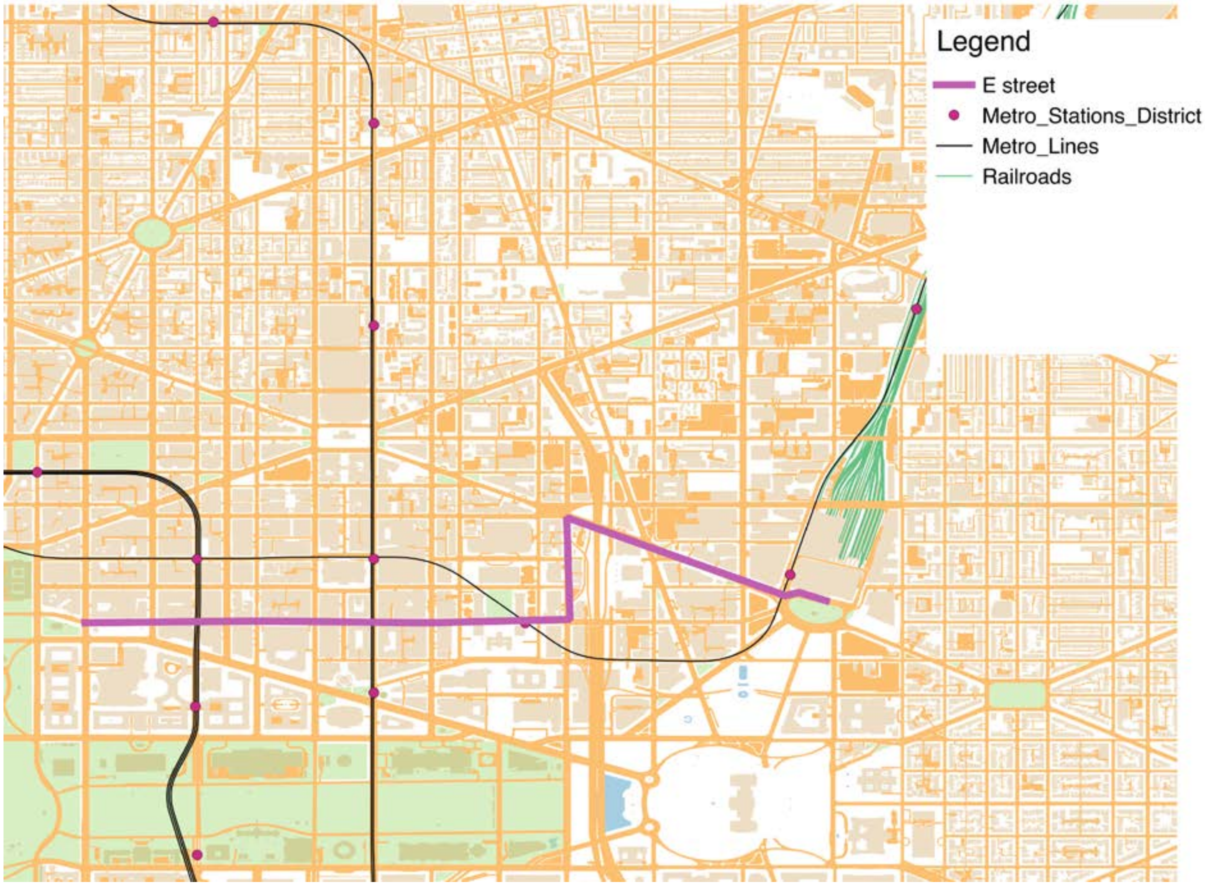
Cost Element	Baseline values, route 1	Scenario route values	Break even point by loading	Break even point by fare
Average Loading	1.49	4.00	2.80	4.00
Passenger Fare	$3.25	$3.25	3.25	2.5
Revenue / day operated	$31.11	$169.23	$118.46	$130.18
Marginal operating cost / day operated	$107.89	$113.25	$113.25	$113.25
Profit / Loss per day operated	-$76.79	$55.98	$5.21	$16.92
Profit / Loss per passenger	-$8.02	$1.08	$0.14	$0.33

Mass Ave Test	Baseline values, route 1	Scenario values
Corridor population	13,844	4,440.68023576533
r value per mile	2411.495215311	1,959.59649122807
Baseline frontage r value	18327.3636363636	5,878.79
Days in service PA	234	234
Trips / day residential	9.57	3.07018590618192
Trips / day transit		49
Annual Trips	2,239.71	12184.4235020466

The H Street route demonstrates the potential to break even from the outset where transit trips divert to the route. This is discussed in the analysis below.

6.3.6 E Street

The third analysis relates to the development of a taxicab shuttle route operating west from Union Station, along E Street, and terminating at 14th Street NW / Pershing Park corner. See Map 8.



Map 8: E Street shuttle route

Table 19: Taxicab shuttle route development - E Street

Cost Element	Baseline values, route 1	Scenario route values	Break even point by loading	Break even point by fare
Marginal cost of production / live mile	$2.21	$2.90	$2.90	$2.90
Route distance (Miles round trip)	7.6	3.4	3.4	3.4
Vehicle trips / day	6.43	12.73	12.7	12.7
Passenger trips / day	9.57	50.91	40.7	50.9
Average Loading	1.49	4.00	3.20	4.00
Passenger Fare	$3.25	$3.25	3.25	2.5
Revenue / day operated	$31.11	$165.45	$132.36	$127.27
Marginal operating cost / day operated	$107.89	$125.49	$125.49	$125.49
Profit / Loss per day operated	-$76.79	$39.96	$6.87	$1.78
Profit / Loss per passenger	-$8.02	$0.79	$0.17	$0.04

Mass Ave Test	Baseline values, route 1	Scenario values
Corridor population	13,844	2,760.42157009331
r value per mile	2411.495215311	1,074.81792717087
Baseline frontage r value	18327.3636363636	3,654.38
Days in service PA	234	234
Trips / day residential	9.57	1.90849305729405
Trips / day transit		49
Annual Trips	2,239.71	11912.5873754068

The E Street shuttle route would also be likely to operate at a profit where focused on transit trip pick-ups and peak hours, described above. A comparison of the Union Station routes is set out in section 7.4 below.

6.4 Union Station Route Analysis

The development of taxicab shuttle services focused on Union Station appears commercially more attractive than those located in suburban locations. A significant part of this benefit is related to the transfer of transit passengers to taxicab shuttle. Of the three Union Station routes tested, two appeared to operate commercially from the outset, with the third, along Massachusetts Avenue, requiring only small subsidies or increased loadings. See Table 20.

Table 20: Union Station taxicab shuttle service profitability and break-even point

Route	Base profit / loss per passenger carried @ $3.25	Fare required to break even, current demand
Mass Ave	-$0.52	$3.80
H Street	$1.08	$2.50
E Street	$0.79	$2.50

Two of the routes tested, those along H Street and E Street could operate successfully at $2.50 per passenger carried. This would also likely increase demand resulting in a greater level of use.

6.4.1 Application of Peer Experiences

In addition to the initial calculation of viability and cost, a further review is applied based on the experiences of peers, including the now defunct Bridj operation. These are summarized in Table 21.

Table 21: Application of Peer Experiences Test

	Mass Ave	H Street	E Street	Wisconsin	Rhode Island Ave	C Street
Primary Audience	Metro users connecting to Union Station	Metro and bus users connecting to Union Station	Metro users connecting to Union Station	Suburban users	Suburban Users, some commuting	Suburban Users, some commuting
Viable alternative to	Metro / Taxi	Metro / Taxi / Bus	Metro / Taxi	Metro / Taxi / Bus	Bus / Taxi	Bus / Taxi
Elasticities PED	Relatively inelastic	Relatively inelastic	Relatively inelastic	Relatively elastic	Neutral	Relatively elastic
Demand patterns	Line based distributor from heavy rail	Line based distributor from heavy rail	Line based distributor from heavy rail	Line based leisure	Line based connector TO Metro and leisure	Line based leisure
Marketing	Required, may match Mass, H and E Streets	Required, may match Mass, H and E Streets	Required, may match Mass, H and E Streets	Required, leisure market	Required, associated with Metro use	Required, leisure market
Matching Fare to above	Metro level	Metro level	Metro level	Bus	Between bus and Metro	Bus

7.0 Conclusion

In the preceding sections, we have set out a methodological approach to the testing of taxicab shuttle routes in Washington, D.C. The analysis includes a method by which levels of demand for shuttle services may be assessed, allowing for a cost-benefit analysis to be undertaken by route. The analysis includes a review of the four existing NRS pilot routes, three new suburban routes, and three city-center routes focused on Union Station, serving a distribution function for station users in addition to residential demand.

The existing NRS pilot routes in their current patterns are unlikely to operate for a profit and would require a moderate to large uptake in the number of passengers before being able to move to profitability.

New suburban routes are also unlikely to operate commercially for a profit, but can be provided at a lower per passenger cost than the NRS pilot routes where the route is constrained in length. We would recommend that such routes should be no greater than three miles long.

While services may not be provided at a profit in all instances, this should not deter from recognizing the social benefits that accrue from providing the service, which also give rise to a value and some financial savings to the public fisc. Taxicab shuttle routes are perceived by passengers to provide a genuine increase in the level of mobility and access of their users, providing social benefits above the commercial benefit realized by the operator; this has long been given as a justification for a public subsidy for transit and similar services.

It is also noted that existing WMATA bus services rely on a public operating subsidy, which can be as high as 95% of the operating cost for poorly-performing bus routes[22]. This does not necessarily justify the allocation of 95% subsidies to the taxicab shuttle, but may highlight the actual level of costs are relatively low compared to some existing Metro services. Indeed this may support the concept of transferring some bus routes to shuttle operation.

Shuttle routes that appear complex and convoluted – including routes that operate on circuits or that serve differing roads on the outward and return trip – are less likely to achieve break-even. Routes shorter less than three miles in each direction appear more likely to break even, with shorter city center routes being able to break even the quickest.

The NRS pilot routes all operated at a loss of $8 to $15 per passenger carried. The loss is partly associated with the lack of sufficient numbers of passengers, but is also associated with the relatively long distances of each route. Simpler and shorter routes may prove effective in providing access to local facilities. In addition to the analysis of the pilot routes, three suburban lines and three city center lines have been tested.

Suburban routes tested included Wisconsin Avenue, Rhode Island Avenue and C-Street. In each of these instances a shorter route has been tested in preference to a longer one. While each of the suburban routes also required a per passenger subsidy, the amount of this was significantly below those seen in the pilot (ranging between $3.50 and $5.50).

City center routes were tested to include the impact of services that served a distributor function from a transit hub, in this case Union Station, in addition to servicing local residential populations. The three routes included Massachusetts Avenue, H Street, and E Street. None of the city center routes are likely to be commercially viable on the basis of residential traffic alone, which is significantly reduced in most city centers, but all three performed significantly better when serving a distribution function for arrivals and departures from Union station.

Surveys of NRS users suggest a high level of satisfaction with the service provided on the pilot routes, but may indicate a lack of route knowledge in some routes from a lack of marketing. Promotional activities should therefore be included as part of route development.

Taxicab shuttle routes operating to and from Union Station are likely to operate commercially without significant subvention in the long run. Of the three Union Station routes we tested, both the E Street and C Street routes are likely to operate at a profit. City center routes should be adopted from Union Station as soon as appropriate facilities can be provided by the station.

In light of the review in this report, we conclude that the following factors should be considered in developing future taxicab shuttle routes:

- Routes should generally be limited in length to three miles in each direction;[23]
- Wherever possible, shuttles should avoid circuitous routes and those that serve different streets in each direction;
- Some flexibility of fare should be reserved to operators, to allow for higher fares where necessary to support the viability of the service;
- Stops and termini should be recognizable and include street furniture (signs and poles);
- Each stop or terminus should provide customers with sufficient information on how to use the service;
- There should be a public information campaign to support the development of the service, particularly at the launch of a new route; and
- Taxicab shuttles should be considered for inclusion in the WMATA Smartrip payment system.

Appendix 1: Trip Count by Route

Day by entry	Route 1	Route 2	Route 3	Route 4
Vehicle trip count	2	4	4	4
Passenger trip count	2	6	5	4
Vehicle trip count	8	5	6	3
Passenger trip count	11	5	7	4
Vehicle trip count	8	6	5	
Passenger trip count	9	8	8	
Vehicle trip count	9	8		
Passenger trip count	13	9		
Vehicle trip count	8	2		
Passenger trip count	13	2		
Vehicle trip count	8			
Passenger trip count	16			
Vehicle trip count	2			
Passenger trip count	3			
Mean Vehicle trip count	6.428571428571 43	5	5	3.5
Mean Passenger trip count	9.571428571428 57	6	6.666666666666 67	4
Pass trips / veh trip	1.488888888888 89	1.2	1.333333333333 33	1.142857142857 14
entry count	7	5	3	2

Note: Data from Transco, March 5 -12

Route 1 Density

	Baseline			Scenario 1			Scenario 2		
	Density / sq mile	**Contact distance to route**	**Sum**	**Density / sq mile**	**Contact distance to route**	**Sum**	**Density / sq mile**	**Contact distance to route**	**Sum**
			0	5126	7	35882	5126	7	35882
	13766	3	41298	13766	3	41298	13766	3	41298
	10550	3	31650	10550	3	31650	10550	3	31650

	Baseline			Scenario 1			Scenario 2		
	Density / sq mile	**Contact distance to route**	**Sum**	**Density / sq mile**	**Contact distance to route**	**Sum**	**Density / sq mile**	**Contact distance to route**	**Sum**
	16600	2	33200	16600	2	33200			
	11314	1	11314	11314	1	11314	11314	1	11314
	18014	1	18014	18014	1	18014	18014	1	18014
	12426	1	12426	12426	1	12426	12426	1	12426
	9688	1	9688	9688	1	9688	9688	1	9688
	19871	2	39742	19871	2	39742	19871	2	39742
	28600	1	28600	28600	1	28600	28600	1	28600
	13400	2	26800	13400	2	26800	13400	2	26800
	21575	2	43150	21575	2	43150	21575	2	43150
	18000	2	36000	18000	2	36000	18000	2	36000
	13200	3	39600	13200	3	39600	13200	3	39600
	16125	1	16125	16125	1	16125	16125	1	16125
	18220	2	36440	18220	2	36440	18220	2	36440
	20100	1	20100	20100	1	20100	20100	1	20100
	27325	1	27325			0			0
	18225	1	18225			0			0
	28760	2	57520			0			0
	9300	3	27900	9300	3	27900	9300	3	27900
	3236	3	9708	3236	3	9708	3236	3	9708
	11122	5	55610	11122	5	55610	11122	5	55610
	20666	3	61998	20666	3	61998	20666	3	61998
	11371	3	34113	11371	3	34113	11371	3	34113
	82628	3	247884	82628	3	247884	82628	3	247884
	7730	2	15460	7730	2	15460	7730	2	15460
	8450	3	25350	8450	3	25350	8450	3	25350
	18820	3	56460	18820	3	56460	18820	3	56460

	Baseline			Scenario 1			Scenario 2		
	Density / sq mile	**Contact distance to route**	**Sum**	**Density / sq mile**	**Contact distance to route**	**Sum**	**Density / sq mile**	**Contact distance to route**	**Sum**
	18833	2	37666	18833	2	37666	18833	2	37666
	22560	4	90240	22560	3	67680	22560	3	67680
				40600	4	162400	40600	4	162400
				51589	4	206356	51589	4	206356
				30300	2	60600	30300	2	60600
				36760	4	147040	36760	4	147040
Mean / Totals	18327.3636363636	66	1209606	20686.0243902439	82	1696254	20788.175	80	1663054

Wisconsin Avenue Taxi shuttle route density

	Baseline		
	Density / sq mile	**Contact distance to route**	**Sum**
	7155	2	14310
	2816	4	11264
	5840	3	17520
	6913	5	34565
	15000	1	15000
	2704	4	10816
	22857	2	45714
	22400	3	67200
	15500	4	62000
	7376	5	36880
	4451	1	4451
	7542	4	30168
	5309	2	10618
Mean / Totals	9012.65	40	360506

Rhode Island Avenue Taxi shuttle route density

	Baseline		
	Density / sq mile	**Contact distance to route**	**Sum**
	6942	6	41652
	9450	2	18900
	5723	3	17169
	12744	2	25488
	2670	2	5340
	11018	1	11018
	20450	0.5	10225
	25450	0.5	12725
	20516	3	61548
	17137	1	17137
	7175	2	14350
	7025	1	7025
	6127	2	12254
	8011	2	16022
	5877	1	5877
Mean / Totals	9542.41379 310345	29	276730

C Street Taxi shuttle route density

	Baseline		
	Density / sq mile	**Contact distance to route**	**Sum**
	3454	5	17270
	12130	1	12130
	1459	7	10213
	21725	1	21725
	22533	1	22533
	3454	3	10362

	Baseline		
	Density / sq mile	Contact distance to route	Sum
	1	5	5
Mean / Totals	4097.30434 782609	23	94238

Mass Ave taxicab shuttle route density

	Baseline		
	Density / sq mile	Contact distance to route	Sum
	567	1	567
	23433	1	23433
	8300	3	24900
	22862	2	45724
	88900	1	88900
	40500	1	40500
	35642	2	71284
	1509	2	3018
	12542	1	12542
	5220	3	15660
	4551	2	9102
	2963	2	5926
	24400	1	24400
Mean / Totals	16634.3636 363636	22	365956

H Street taxicab shuttle route density

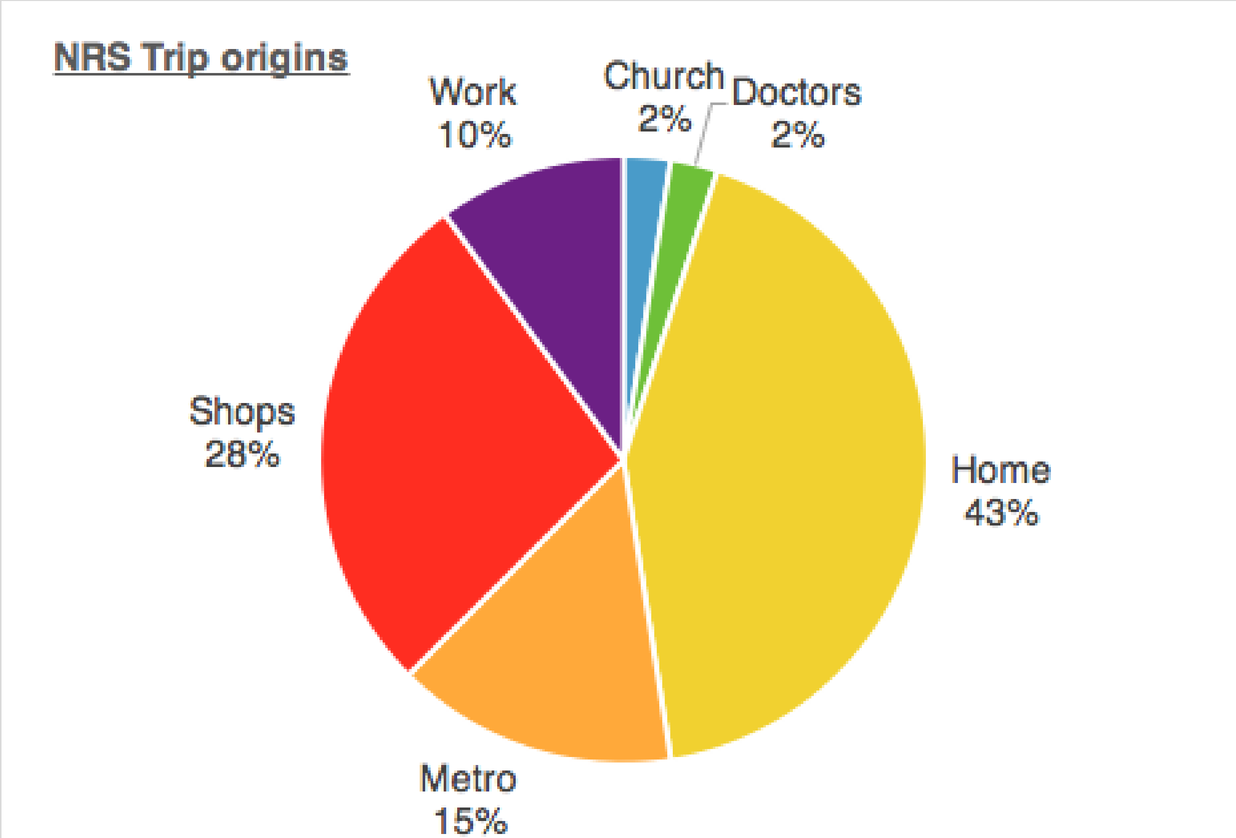
	Baseline		
	Density / sq mile	Contact distance to route	Sum
	567	1	567
	23433	2	46866

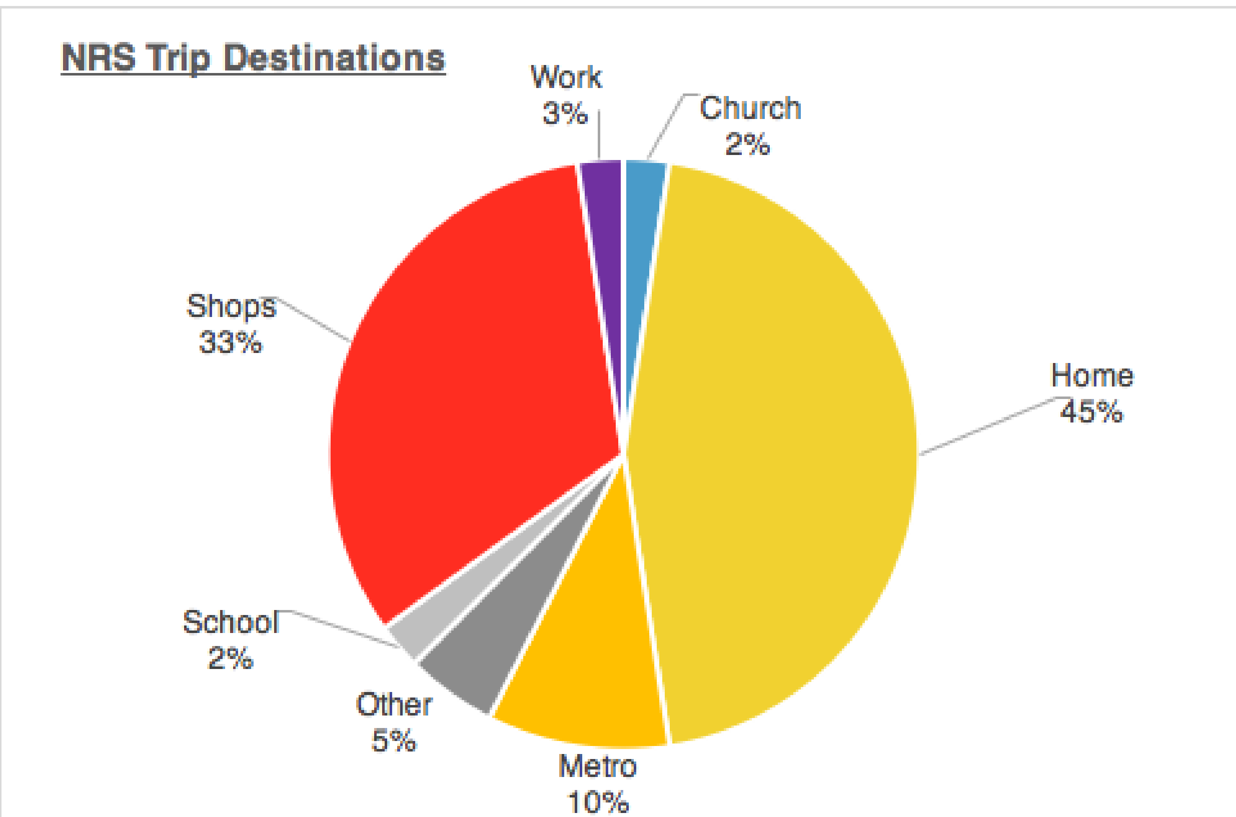
	Baseline		
	Density / sq mile	**Contact distance to route**	**Sum**
	8300	1	8300
	2963	1	2963
	4551	4	18204
	5220	1	5220
	4551	4	18204
	2963	2	5926
	2440	2	4880
	567	1	567
Mean / Totals	5878.78947 368421	19	111697

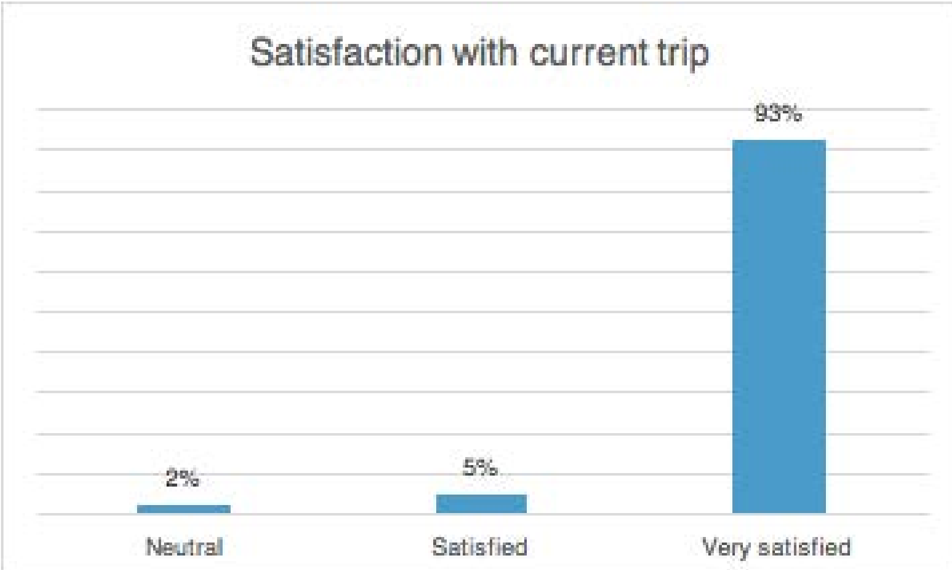
E Street taxicab shuttle route density

	Baseline		
	Density / sq mile	**Contact distance to route**	**Sum**
	567	1	567
	8300	1	8300
	2963	4	11852
	4551	8	36408
	2963	5	14815
	2400	2	4800
Mean / Totals	3654.38095 238095	21	76742

Appendix 2: Public Survey

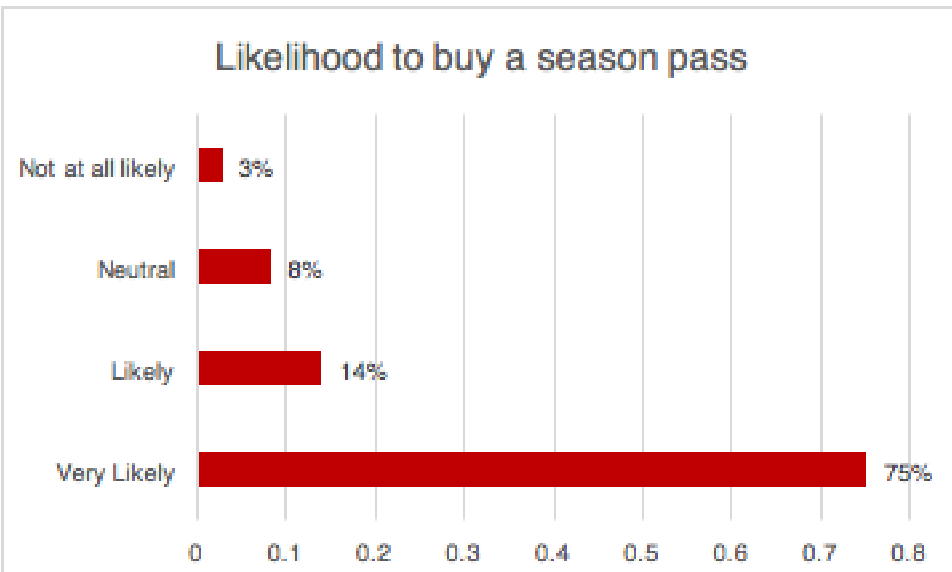




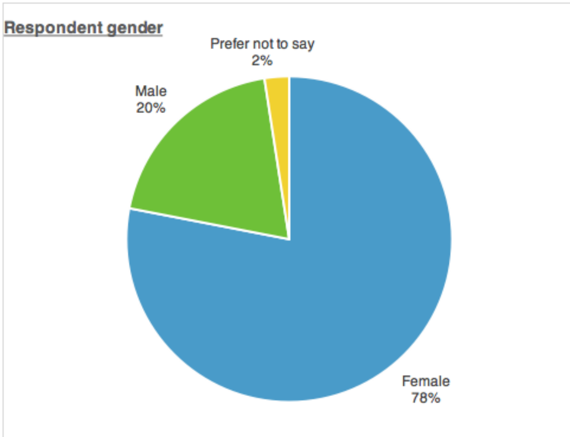

Satisfaction with current trip
93%
2%
5%
Neutral
Satisfied
Very satisfied

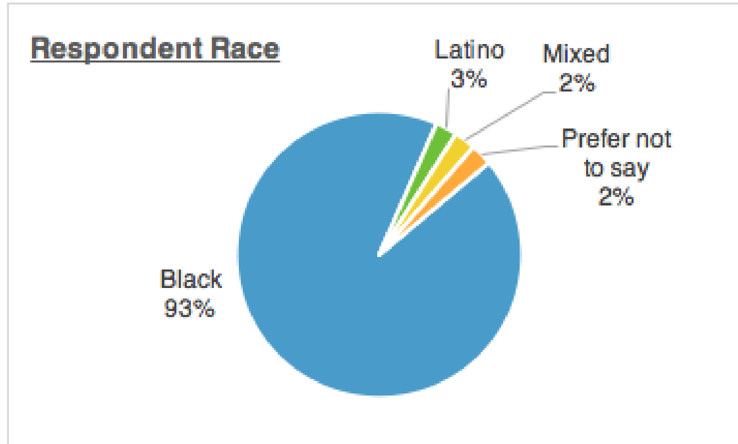

Satisfaction with routes currently offered
93%
2%
5%
Neutral
Satisfied
Very satisfied

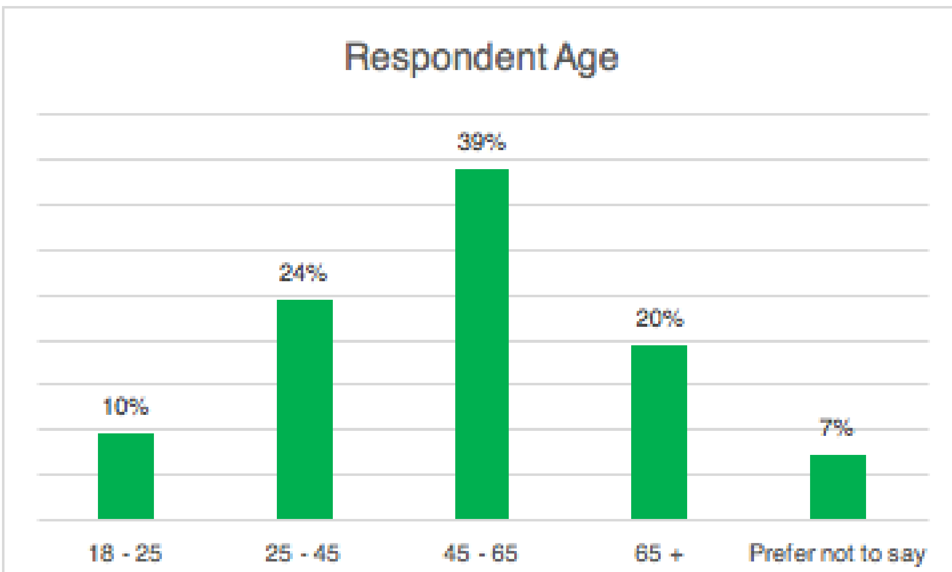

Satisfaction with price charged
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
95%
5%
Satisfied
Very satisfied


Likelihood to buy a season pass
Not at all likely
3%
Neutral
8%
Likely
14%
Very Likely
75%
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

Demographic







ENDNOTES

[1] See RFA #NVS2016-01-001 grant application at https://dfhv.dc.gov/node/1133562 ("Companies will provide Neighborhood Van Service according to customers' needs. Transportation will be provided as jitney-style service, where passengers are picked up and dropped off along fixed or variable or predefined routes within and between Wards 4, 7, and 8. The service will run 24 hours per day, 7 days per week or at timeframes optimized for customers' benefit.").
[2] Other cities include: New York, NY: Dollar Vans; Belfast, NI: Taxibus and Black Taxi; Istanbul, Turkey: Dolmus; Cape Town, South Africa: Taxi Brousse, etc.
[3] While not taxicab services, the shared-ride services provided by these transportation network companies (TNCs") (called "private sedan" or "private vehicle-for-hire" businesses in the District) are vehicle-for-hire services sufficiently similar to warrant inclusion here. These services are often marketed in terms of a lower cost when compared to 'traditional' TNC services, and take advantage of the matching capabilities of TNC software (apps).
[4] Bridj services were suspended for a three-month period in Fall 2016 and completely ceased operation in May 2017. See section 5 of this document.
[5] Differing service patterns can include a combination of differing route types (circular, linear and composite), time and operating patterns set out in subsequent sections.
[6] Vehicle purchase and maintenance costs have been excluded from this initial assessment of NRS because the pilot program supported the acquisition of new vehicles, unlikely to require major servicing in their initial operations. These costs, however, should be built in to future analyses, with a typical annual vehicle and infrastructure cost of $4,875 (including vehicles deprecated over an eight-year life).
[7] This may vary in some instances to accommodate observed areas of high demand beyond three miles.
[8] Marginal costs relate to costs experienced for producing one additional unit. The figure shown in Table 1 does not include any capital/vehicle costs as these are subject to a vehicle grant scheme. See above note 4.
[9] Traffic flow trends for route 1 indicate that a potential exists for this route to break even over time.
[10] The data used to prepare Tables 5-8 was obtained from Transco.
[11] Figure is rounded.
[12] See Brake et al. (2006).
[13] Uber Blog.
[14] Source: DCGIS Open Data, Demographic.
[15] Census block groups by 2000 population density, DCGIS Open Data, Demographic.
[16] Definitions taken from the TPB Travel Forecasting Model.
[17] This includes Metrorail. Sources:
https://ggwash.org/view/41234/all-91-metro-stations-ranked-by-ridership;
https://www.amtrak.com/pdf/factsheets/DC11.pdf;
http://www.vre-ghx.org/site/wp-content/uploads/2015/11/Fact-Sheet_16NOV15.pdf;
https://data.maryland.gov/Transportation/MTA-Average-Weekday-Ridership-by-Month/ub96-xxqw
[18] Source: https://comp.ddot.dc.gov/Documents/Union%20Station%20Intermodal%20Transportation%20Center%20Feasibility%20Study.pdf
[19] Sources: http://www.metrobus-studies.com/North%20Capitol/North%20Capitol.htm;
http://www.metrobus-studies.com/MSE%202012%20E.Capitol/East%20Capitol.htm;
http://www.metrobus-studies.com/Benning-H/Benning-H.htm.
[20] Source: Metrobus Monthly Ridership June 2016 Bus Line, Sector and Jurisdictional Summary.
[21] Sources: http://www.metrobus-studies.com/North%20Capitol/North%20Capitol.htm;
http://www.metrobus-studies.com/Benning-H/Benning-H.htm;
WMATA 2016-06-JCC-June-2016-bus-ridership.
Note: percentage allocation at Union station was estimated at mid-point for lines D1, D3, D6, D8 and X2.
[22] Source: https://www.washingtonpost.com/news/dr-gridlock/wp/2016/10/31/metro-budget-proposal-kills-14-bus-lines/?utm_term=.c78bfd49a768.
[23] This may vary in some instances to accommodate observed areas of high demand beyond three miles.