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Resurgence of Demand Responsive Transit services – Insights from BRIDJ trials in Inner West of Sydney, Australia

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TITLE: **Resurgence of Demand Responsive Transit services – Insights from BRIDJ trials in Inner West of Sydney, Australia**

ABSTRACT:

This paper outlines the key insights gained from the Demand Responsive Transit (DRT) operations in Inner West Sydney, since its commencement in July 2018. It was identified that DRT can play a number of roles to complement the general public transport network, including the (1) peak feeder function, (2) connection function, and (3) coverage function. As a result, if successfully integrated with the existing public transport network, DRT can unlock broader fixed route network enhancements through resource reallocation to the key trunk routes. While the patronage for DRT services was found to steadily increase since the commencement of the operations, the key barrier for these services to attract further regular patronage remains the relatively higher fares arising due to the lack of Opal benefits such as mode transfer discounts or weekly caps. Therefore, while DRT has great potential to link those in less connected areas with public transport hubs, thus facilitating a modal shift away from private vehicles, they need to be affordable and well regulated. In the near future, DRT services will likely be integrated into MaaS applications, which could provide immense benefits in terms of sustainable travel and the effective utilisation of road network capacity.

KEY WORDS: ***Demand Responsive Transport; Sydney Public Transport; Land Passenger Transport***

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1. Introduction

Demand-responsive transit (DRT) is a form of public transit that is characterized by flexible routes and schedules, which generally uses small to medium sized vehicles to provide door-to-door or stop-to-stop/hub services in response to passenger journey requests. Historically, the cost of providing DRT services by either the private or public sector, has been high, in part due to limited patronage in many of the contexts in which it has been introduced, requiring high levels of subsidy. As big a concern as low patronage has been high cost, as additional administrative resources have been required to "dynamically schedule" services according to demand, and to receive and analyse requests which were traditionally delivered by telephone. Also, DRT has often been perceived as institutionally challenging, in part due to the very rigid nature of many tendered or negotiated bus contracts (of a gross cost form), and as a result the supply of DRT services in many jurisdictions has, in the past, been either not allowed or where introduced, discontinued.

The digitally inspired transformation in recent years has offered a new environment, in which customized services that are more user focused have emerged as of growing interest to governments throughout the world. Governments are now actively encouraging the introduction of more flexible user-centric services, of which the provision of DRT services has moved to the mainstream, in contrast to being a niche activity. Private bus operators are being encouraged to consider such flexible services either within their existing mix of contracted services or as additional offerings either under a contract extension or as a market driven economically deregulated initiative as entry barriers are removed.

In general, technological advancements enable DRT operators to deliver improved services for passengers with higher levels of operational efficiency. Furthermore, with the advent of car-based services such as Uber and Uber pool and increasing costs of fuel and vehicle ownership, some segments of the public have been more receptive to considering alternative modal options to owning a car (at least a second car), with increasing willingness to consider using shared transportation services. As DRT trials in particular increase, and ongoing services are modified with small injections of DRT services, it becomes important to understand the principles of operational success and financial viability which underpin the recent resurgence of DRT services, so as to avoid the concerns from the past.

This paper documents the insights gained from the recently commenced DRT operations by BRIDJ in Inner West area (referred to as Region 6) in Sydney, Australia, which is linked to a recently won contract through competitive tendering that explicitly encouraged DRT in the bid service mix. The Region 6 strategic network plan involves BRIDJ services being introduced as feeder services into trunk transport hubs with more efficient coverage services to fill the coverage gaps. By doing so, it is envisaged that BRIDJ can provide more efficient and customer friendly 'first and last mile' and local services, while at the same time facilitating upgrades on the trunk bus network to 'turn-up-and-go' style services (i.e., reallocation of large bus resources to trunk corridors with headway frequency). This has enabled BRIDJ to gain unique insight into planning DRT that incorporates and takes into consideration the broader public transport network. This work illustrates the effectiveness of a multi-delivery of service model, involving DRT operating in conjunction with regular public transit vehicles, within a contracting model of service provision.

2. Literature Review

2.1 DRT's transition from niche markets to mainstream

DRT is a user-oriented form of passenger transport and, unlike conventional public transport, is characterised by flexible routes and/or timetables according to passenger needs, with smaller vehicles operating between pick up and drop off locations. DRT is not necessarily a new concept – it initially emerged in the 1970s to serve the specialist niche markets of remote communities and mobility impaired people, such as the elderly and those with disabilities affecting their mobility (Davison et al., 2014). As a result, DRT has historically been viewed as inefficient and expensive to provide.

However, since the turn of the century, DRT systems are increasingly becoming a mainstream public transport mode. The reasons for this are manifold. Firstly, due to the advancements in the information and communication technology (such as smart phone apps and computer aided dispatching systems) within the last two decades, it has become possible for the operators to provide DRT services more efficiently and cost-effectively than in the past (Palmer et al., 2004). In particular, compared to the traditional "dial-a-ride" services, the now usual practice of mobile apps to receive bookings and the use of advanced algorithms to dynamically schedule services has automated and optimized the key functions and enabled administrative requirements for DRT to be equivalent or less than that for traditional fixed route services. Secondly, with more people living in cities than ever before and the ever-increasing use of private vehicles causing congestion and greenhouse gas emissions, authorities are actively pursuing ways to support greater use of low-carbon mobility solutions which are also more convenient for the users than the conventional public transport services. Finally, the emerging trend of Mobility as a Service (MaaS) is a testament to the fact that there is an increasing appetite by the users for sharing economies, such as Uber, which involve flexible ways of travel for the passengers in a vehicle they do not own, without the burdens of registration costs, tolls or parking (Hensher, 2017).

2.2 Key lessons learnt from past failures

Based on literature (INTERMODE Consortium, 2004; Enoch et al., 2006; Brake et al., 2006), some key lessons from past DRT trials can be summarised as follows;

- **Technological issues:** Translink in Shellharbour NSW, Australia trialled DRT services in early 1990s. This trial did not succeed due to the technical problems arising from lack of planning and over reliance on untested technology, which ultimately led to operator dissatisfaction and loss of enthusiasm. As a result, the operators reverted to a normal service.
- **Managing the right level of service flexibility:** Dial-a-bus scheme in Adelaide, South Australia was an untimetabled 'many-to-many' service which did not succeed as it did not have sufficient passenger demand and was simply too flexible to be practical. While the removal of spatial and temporal aggregation of passengers increased flexibility, it also reduced the efficiency of public transport and the ability to group trips. For situations with low levels of demand, a less flexible service (a pre-booked service, or one with fixed running times) is considered most suitable, as high levels of flexibility can only be achieved if there is sufficient passenger demand.
- **Fare structure:** The Milton Keynes Dial-a-Bus trial in UK could not succeed mainly due to the fares which were too low. In particular, after being cut back to off-peak

DRT services only, the operational costs of this scheme were higher than that budgeted. Eventually, there was insufficient political commitment to keep the scheme alive.

- **Partnerships:** For the DRT services which are public policy-led, it is crucial to have a contracted operator who believes they have something to gain from the success of the scheme. Lack of enthusiasm by the operator seems a key reason for the failure of many DRT trials in the past. In contrast, commercially led DRT services are vulnerable to a hostile attitude from the local authorities. Therefore, the success of DRT schemes often depends heavily on the effective partnership between several actors.
- **Marketing:** Lack of marketing in the Shellharbour trials resulted in disappointing patronage. In the past, there has been resistance by customers for ride sharing (although this attitude is now fast changing, with advent of shared economies such as Uber Pool). Therefore, good marketing and presentation to inform users' expectations is crucial.

3. Background of BRIDJ

In 2017, Transit Systems bought BRIDJ, an on-demand shuttle bus brand that started in Boston in 2014. BRIDJ's technology was the primary reason for this acquisition by Transit Systems, as it was perceived to be a potential solution for decentralised cities. In early 2018, Transit Systems won Australia's biggest-ever tendered metropolitan bus contract which saw the outsourcing of the operations of some 600 buses, which are expected to service 50 million passengers per annum, in Sydney's Inner West from the beginning of July the same year (these services are expected to be extended to Sydney Olympic Park area, in the near future). This contract is unique since it was awarded with an integrated DRT component that will see up to 10 DRT zones being implemented over time, in combination with the broader network improvement plan.

The Inner West services provided by Transit Systems' BRIDJ are a part of the Region 6 contract with Transport for NSW (TfNSW), and are designed to serve niche areas of demand that cannot be efficiently met by full-sized buses. In particular, this route covers the 'first and last mile' gaps between existing transport hubs, making it easier to get around the local area (see **Figure 1**). In addition to the Inner West services, a second set of BRIDJ services are based in the Eastern Suburbs of Sydney and are part of a series of trials conducted by TfNSW, which aim to demonstrate the value or otherwise of introducing this type of service to the "service mix" in Sydney. However, unlike the services in the Inner West area, the Eastern Suburbs services are not a part of the contracting model and are short-term trials.

Figure 1. Route overview for the BRIDJ services operating in Sydney's Inner West

The primary purpose of the Region 6 BRIDJ services is to act as a feeder to and from train stations, especially in the peak periods. In particular, during the peak periods, patronage and directness is a greater focus than coverage. However, during intra-peak, late night and weekend periods, the focus shifts more towards coverage. Providing connections to Burwood shopping district and local village shops is considered to be the secondary purpose of the BRIDJ services.

The target customers for these services are the regular commuters in peak periods, wishing to connect to trains at either Strathfield or Burwood. The target customer base shifts more towards ad-hoc users during off-peak periods.

The customers who book the BRIDJ service via the mobile app are directed to a nearby location to get on board (see **Figure 2** for BRIDJ app customer interface). Payments can be either by a credit card or through OpalPay (Sydney's smartcard system). The regular service fee is a $3.20 (flat fare), and concession tickets are available at $1.60. The BRIDJ service operates between 6am to 11.30pm on weekdays and between 8am to 8.30pm on weekends and public holidays. The service frequency is every 30 minutes, with a reduced frequency of every 60 minutes between 7pm to 11.30pm on weekdays. During peak periods, 4 x 18-seater vehicles (fully accessible), each of which can accommodate a further 8 standing patrons are operational. **Figure 3** illustrates a typical BRIDJ DRT vehicle.

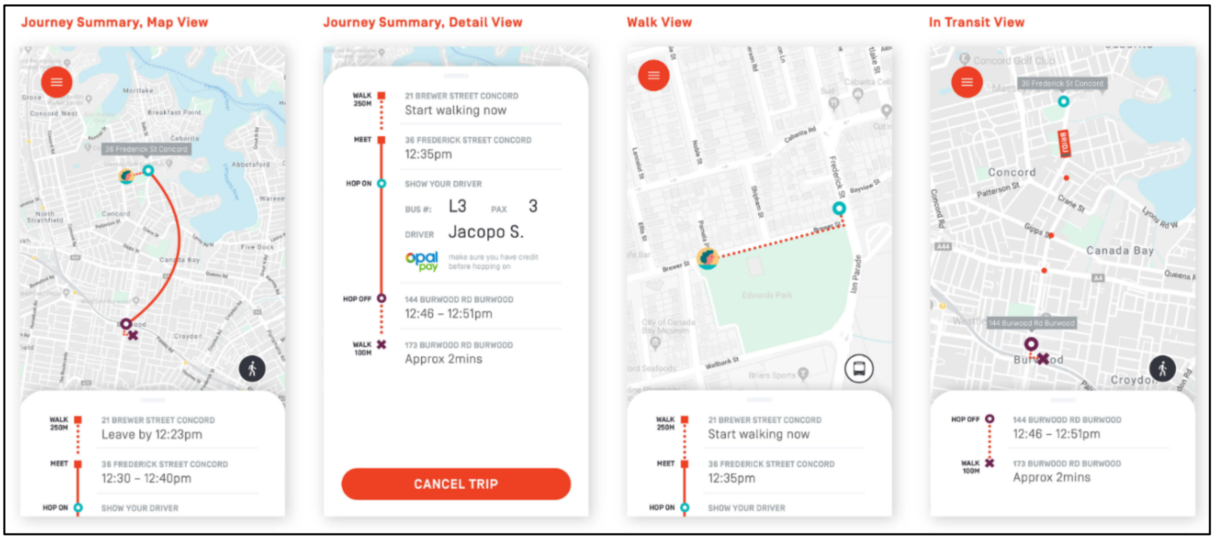

Figure 2. BRIDJ app user interface

Figure 3. A BRIDJ DRT vehicle

4. Analysis Results of BRIDJ Operations

The disaggregate passenger booking data were obtained for the Region 6 BRIDJ services, for the period between 1st of July 2018 (when the services commenced) and 31st March 2019. During this 9-month period, there were a total of 21,138 bookings (through the BRIDJ mobile app) with 90% using Opal cards and 10% using the credit cards, for payment.

4.1 Bookings analysis

Table 1 summarises the number of passengers per booking. As can be seen, the majority of the bookings are for a single passenger (indicating commutes to work by individuals), with rare instances of bookings made up to a maximum of 5 passengers.

Table 1. Number of Passengers per Booking

Number of Passengers	Number of Trips	Percentage of Trips
1	19,359	91.58%
2	1,424	6.74%
3	271	1.28%
4	59	0.28%
5	25	0.12%

Figure 4 illustrates the distribution of the time in advance the bookings are made (i.e., the difference between the scheduled pick-up time and the time of booking). It is clear that the majority of the trips are booked 5 to 20 minutes in advance. **Figure 5** illustrates the average time in advance the bookings are made, for various pick up times across the day. It is interesting to note that during the AM peak period (7-9am), the average time in advance a booking is made is approx. 3.5 hours, while during the PM peak period (4-6pm) it is just under one hour.

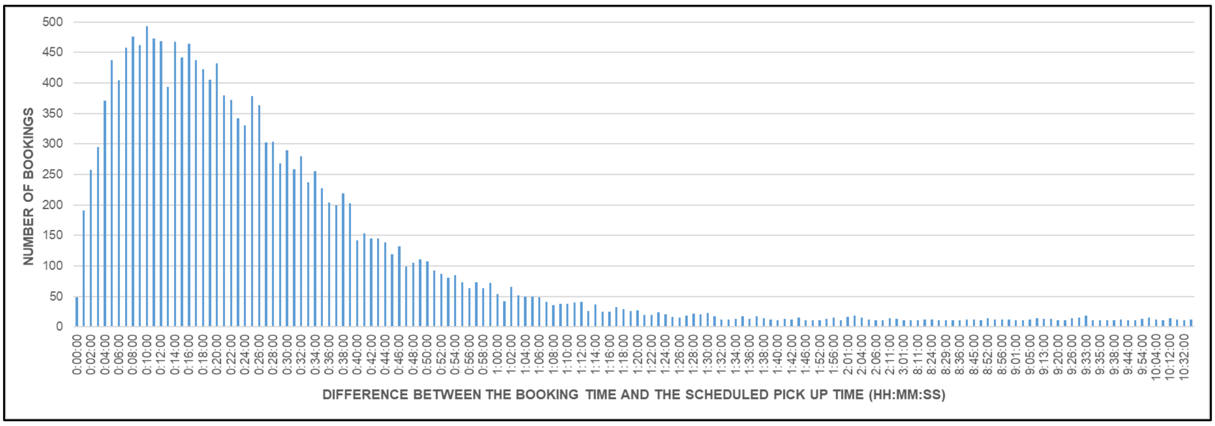

Figure 4. Distribution of Time in Advance the Bookings are made

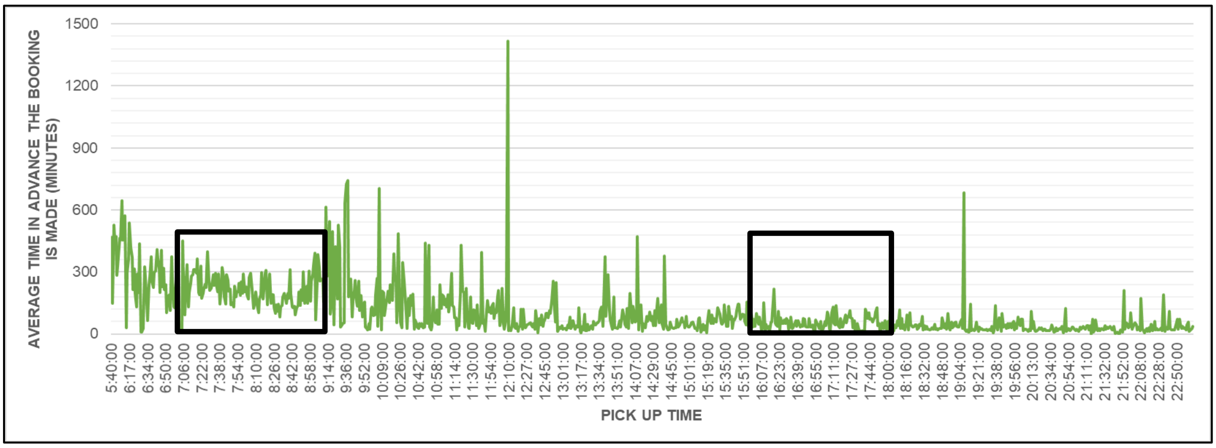

Figure 5. Average Time in Advance Bookings are made for various Pick Up Times

4.2 Patronage analysis

Figure 6 illustrates the weekly patronage levels for Region 6. It is evident that the weekly patronage levels have steadily been increasing since the beginning of the operations in July 2018, with a clear drop in patronage levels during the 2-week holiday period in December.

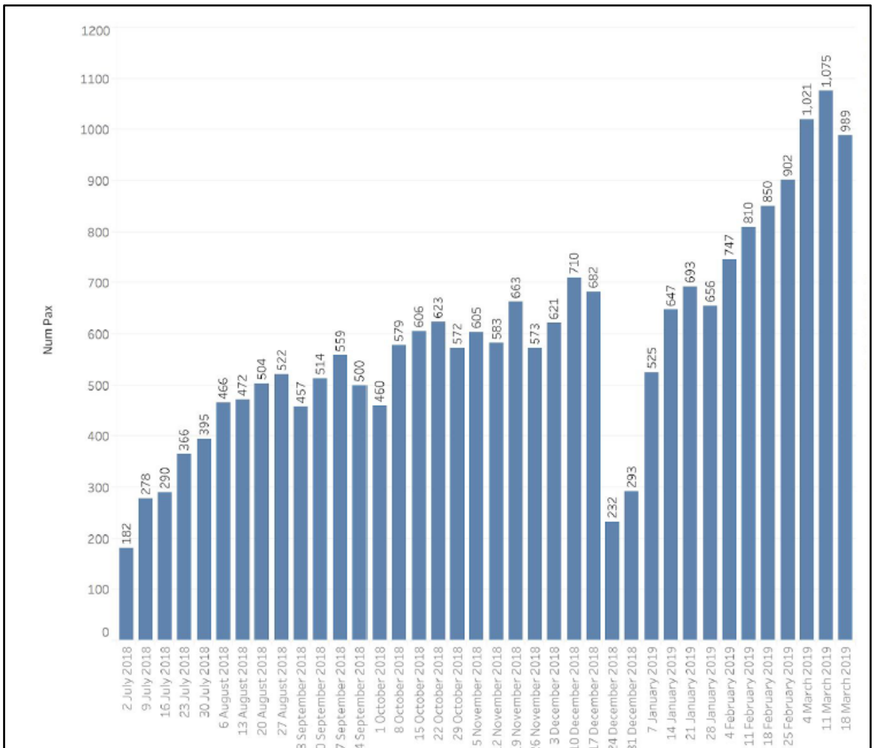

Figure 6. Weekly Patronage Levels for Region 6

Figure 7 and **Figure 8** illustrate the number of pick ups and drop offs at various times of day, respectively. The results are in line with expectations – i.e., both pick ups and drop offs peak during commuter peak periods (between 7am to 9am and 4pm to 7pm).

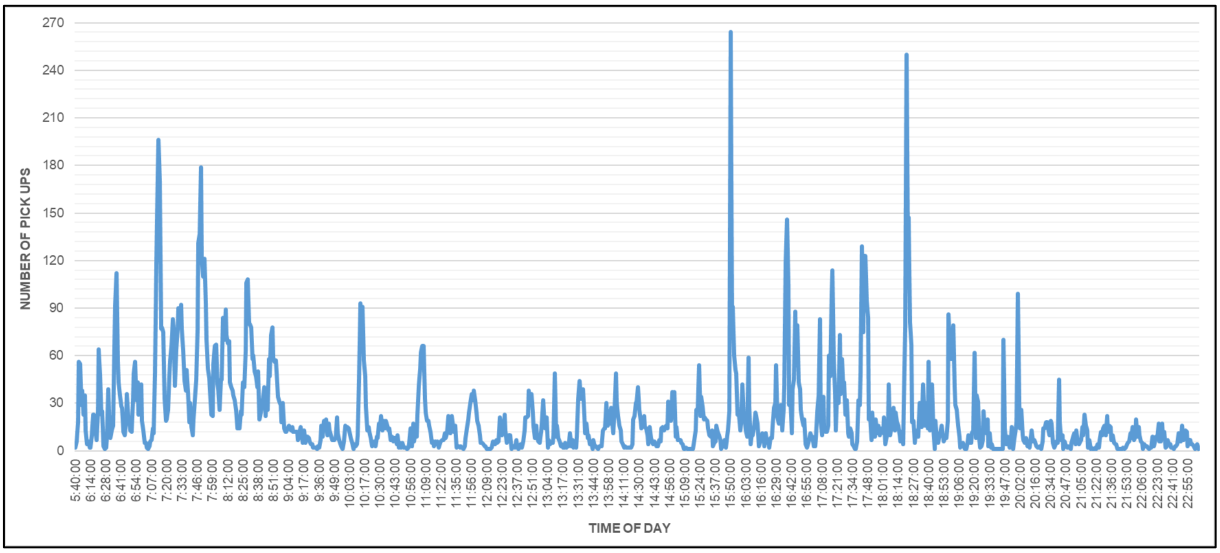

Figure 7. Number of Pick-ups at Various Times of Day

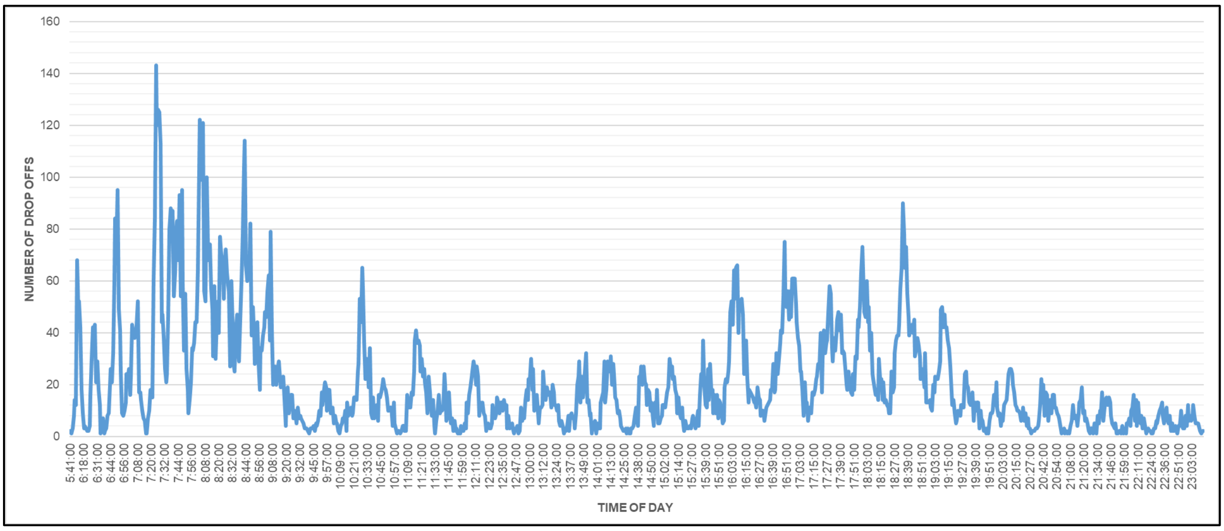

Figure 8. Number of Drop-offs at Various Times of Day

4.3 In-vehicle time

Figure 9 illustrates the in-vehicle times for the trips considered. The distribution of in-vehicle times is approximately normally distributed with a mean in-vehicle time of 12 minutes.

4.4 Reliability analysis

The service reliability can be characterised by the difference between the scheduled and the actual times for both pick-ups and drop-offs, respectively (see the results shown in **Figure 10** and **Figure 11**). It is clear that there are relatively low levels of variation between the actual and scheduled pick-up times (majority of the pick-ups occur within the same minute as scheduled). However, the drop-off times include relatively higher levels of variation between the actual and scheduled times. Therefore, the pick-up times are more reliable than drop-off times. This, in some ways, is by design and is going through an evolution. Generally, pick-ups are harder to predict/control, thus a tighter constraint is made in the system to reduce the variability (i.e. to ensure that the demand is aggregated well and the passengers are where they need to be when the vehicle arrives at their stop). However, as the BRIDJ optimisation engine evolves, the operators are loosening this constraint and it is becoming more about comparing what and how well they communicate service information (such as ETAs and service updates) to the customers. The accuracy of the drop-off and pick-up time predictions are expected to improve in the future as forward prediction and machine learning starts to mature.

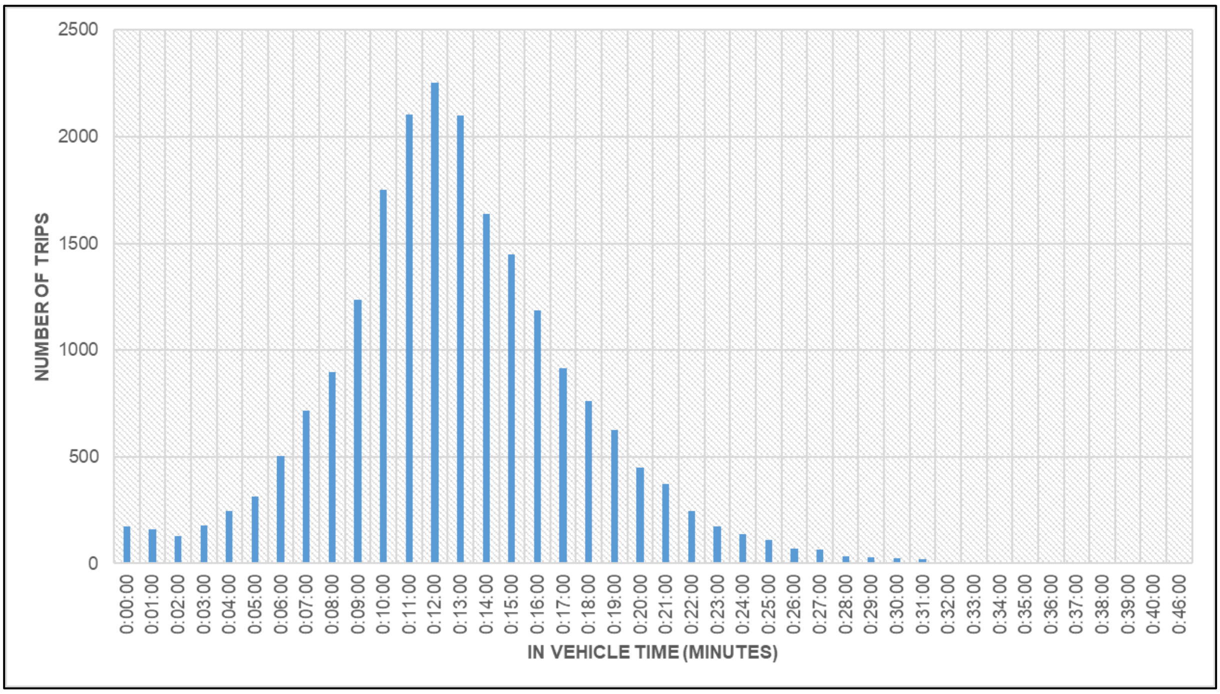

Figure 9. In Vehicle Time Distribution

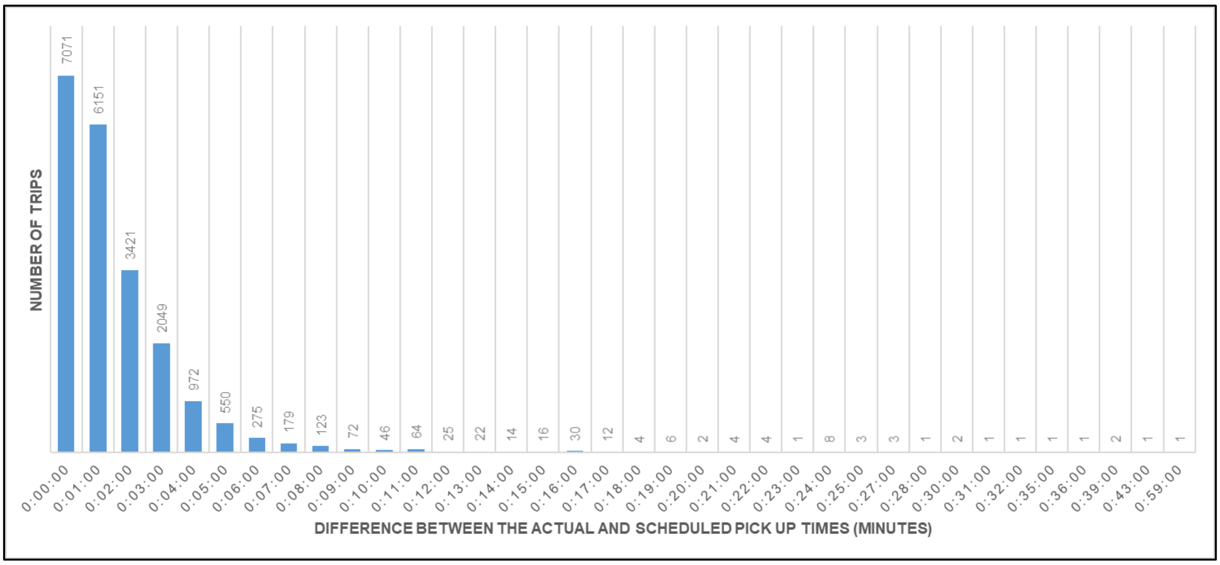

Figure 10. Actual versus Scheduled Pick-up Times

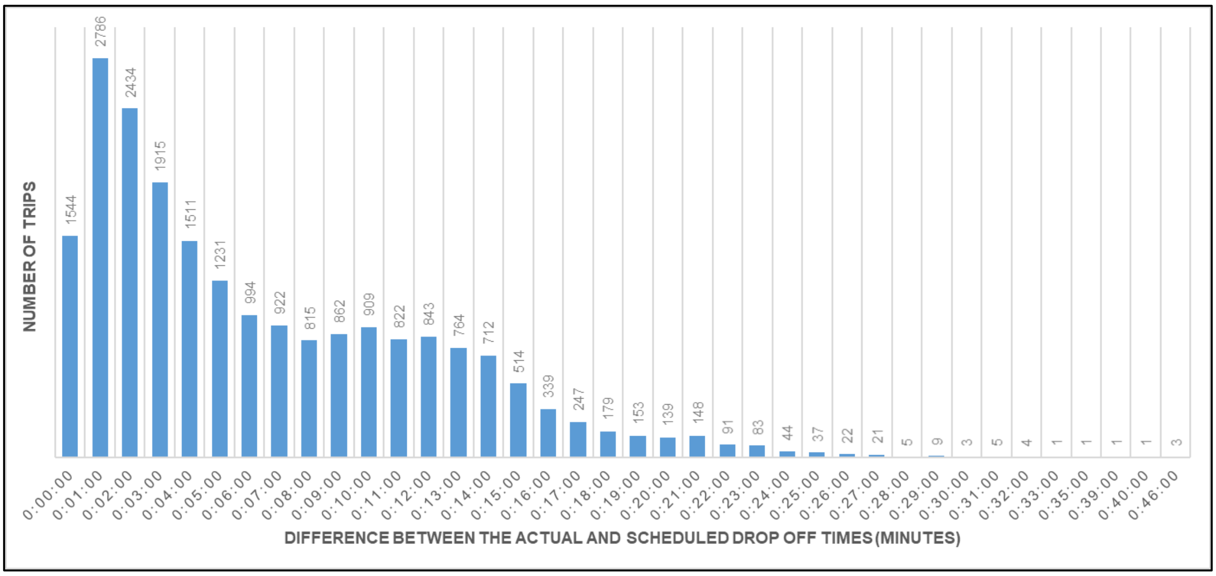

Figure 11. Actual versus Scheduled Drop-off Times

5. Discussion

5.1 Role of DRT in the general public transport network

DRT can play several roles in the general public transport network. These roles can vary based on location, local attractions and time of the day / year, as well as due to environmental, social and economic settings. For instance, the Region 6 BRIDJ services have a variety of objectives, which can be broadly categorised as follows.

1. Peak feeder function: The primary service goal of the Transit Authority is generally higher patronage for peak services. In particular, the more customers the DRT services can attract onto a single trip to feed the trunk PT services, the better off the traffic system as a whole since it, (1) makes accessing the trunk PT services easier and as a result takes private vehicles (whether personal car trips, taxi, rideshare, family drop off or park'n'ride) off local roads and trunk routes, and (2) increases fares on the trunk PT system. **Figure 12** illustrates the locations of pick ups and drop offs, at various times of the day (for the period the data is available) – as can be seen, Strathfield station sees the majority of drop offs and pickups, during the AM and PM peak periods, respectively.
2. Connection function: Here, the primary role of DRT is to be more of a local connection service. This function is particularly suitable for inter-peak periods, where connections to trunk PT services is still a requirement but the parameters are more flexible than morning/evening peak periods, thus making additional connections possible. In essence, this reflects a change in customer requirements and the demand profile, i.e. during inter-peak periods, there may be proportionally fewer people needing to access the trunk PT services and more people wanting to get around their local area to shops, appointments etc.
3. Coverage function: It is worth noting that the suburban feeder networks are, in general, the most ineffective and inefficient parts of the broader PT network. In particular, the coverage function is the most inefficient and ineffective, especially when serviced with a fixed service. While the objective of the coverage function is to

cater for everybody and every trip, over a large area, in reality it ends up doing very little for most. DRT can play more of a coverage function if the area is lower density but there is still a desire to provide a level of service. In particular, DRT can often cover greater areas and still address the real-time demands more effectively (the response times/customer wait times, can be far shorter and the “effective” frequency far higher, compared to a fixed service).

5.2 Key lessons from BRIDJ operations in Region 6

5.2.1 Connections

BRIDJ services in Region 6 provide two main connections as follows;

1. Mortlake to Strathfield and then onto Burwood (2 vehicles in peak periods)
2. Cabarita to Burwood and then onto Strathfield (2 vehicles in peak periods)

To date, the Strathfield station is by far the most popular train connection due to the higher frequency and the number of express trains services that can be accessed from Strathfield (towards the CBD), relative to Burwood (as of 27th March 2019, since commencement of BRIDJ services, there were a total of 16,448 passengers connecting to and from Strathfield compared to only 3,660 at Burwood). The above case also applies to those connecting from Cabarita via Burwood, with almost double the passengers choosing to bypass Burwood to access the express train services from Strathfield station (se evident from the results shown in **Figure 12**).

This observation provides evidence to support a restructure of resource allocation based on passenger demand. The following figures illustrate the origin and destination locations of passengers using BRIDJ services. **Figure 13** shows the current public transport map for the same local area. As can be seen, there exists no bus service which can directly connect the patrons originating from these areas to Strathfield station.

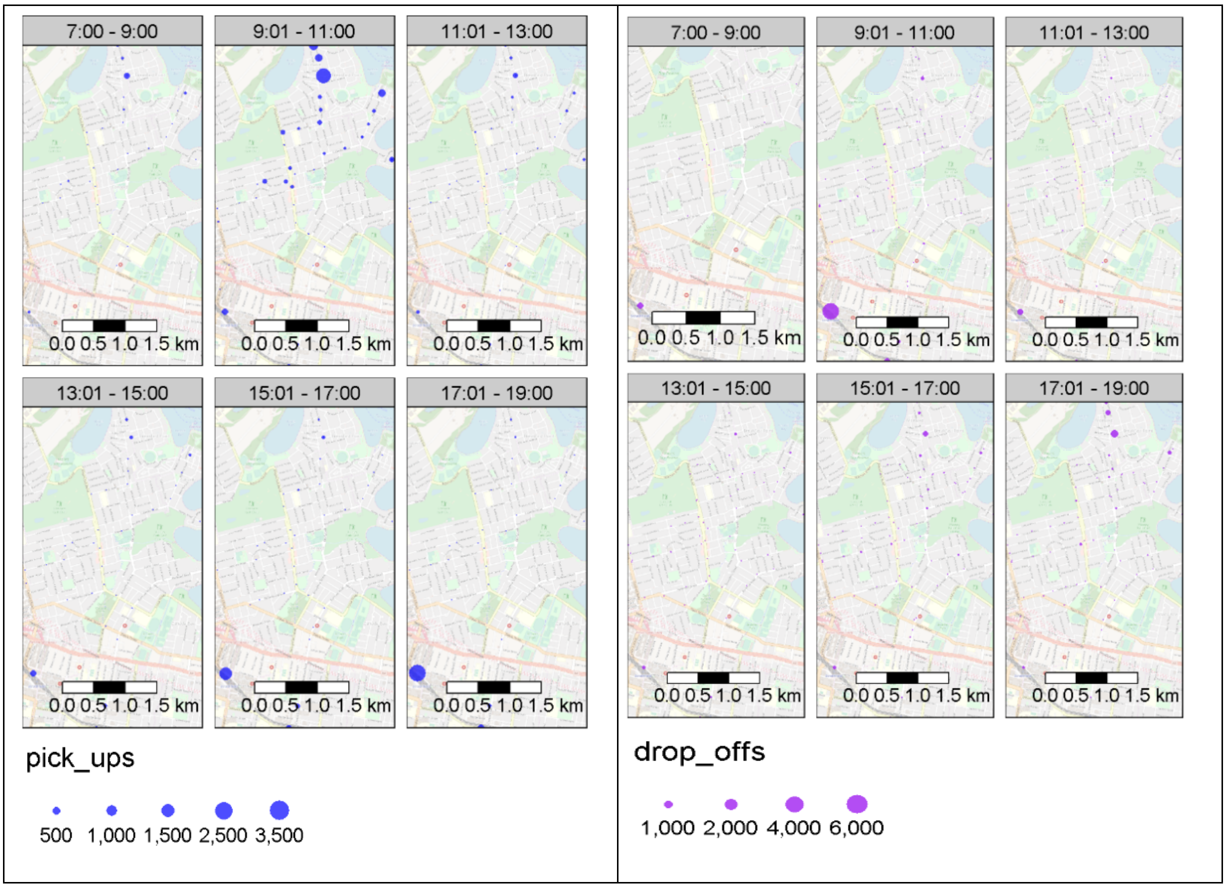

Figure 12. Pick up and drop off locations by times of day

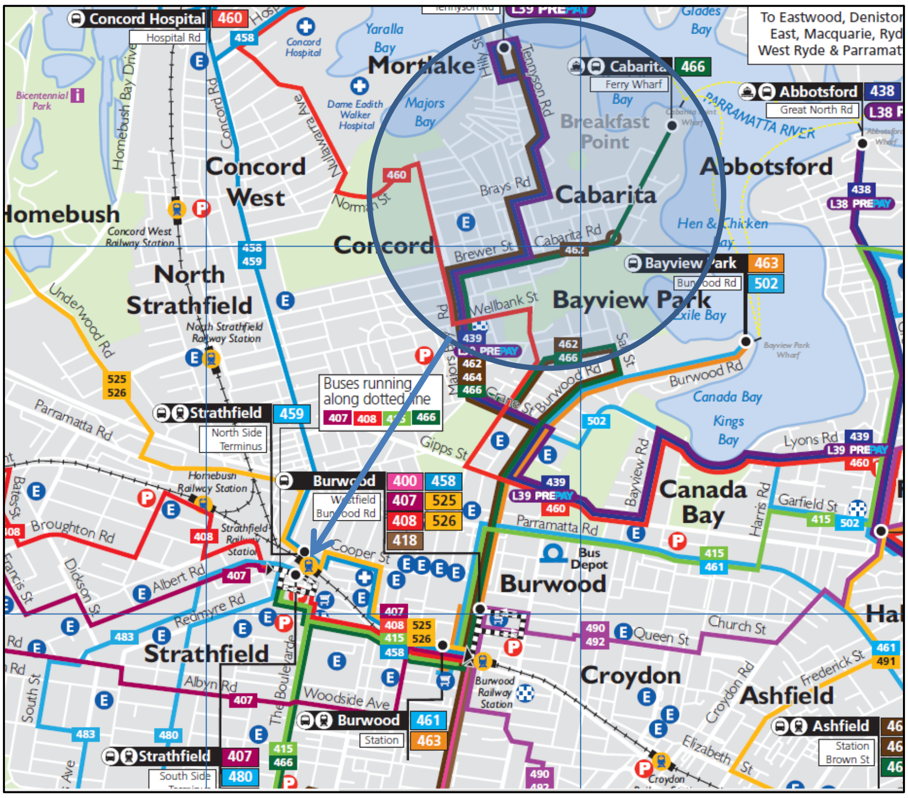

Figure 13. Regular PT Map for Region 6

5.2.2 Optimising the service delivery structure

The BRIDJ optimisation engine takes information and automates optimized responses in real-time by allocating passengers into vehicles in a way that makes those individual vehicle journeys as direct and quick as possible. In particular, it is adaptable to different service objectives in different locations and times of the day. For instance, customers travelling in the peak periods are more interested on their travel times and the directness, frequency, and reliability of the service (for example, the operators can add a constraint, into the optimisation engine, to hit a ferry stop at a certain frequency to ensure connections are made). In contrast, during off-peak periods, convenience and connection flexibility becomes more important and as a result the DRT vehicles can roam more freely.

An optimal service delivery format enables the operators to mimic the common travel demand habits, cater to largely inbound and outbound peaks to popular working locations, and prove point-to-point services in the off-peak times with reduced resources. The future software development roadmap for BRIDJ needs to be framed around delivering the above targets.

5.2.3 Competition

The BRIDJ services on the Cabarita to Burwood connection compete almost directly with the existing fixed route services. Since currently there is no transfer discount onto connecting trains, customers using BRIDJ services to access trains at Burwood face higher fares. Lack of transfer discounts is a major impediment for the growth in patronage for BRIDJ services. The BRIDJ services connecting Mortlake and Strathfield does not compete with fixed routes services (see **Figure 13**) and as such has delivered much higher patronage compared to the Cabarita – Burwood services.

5.2.4 Customers

A widespread awareness effort is needed to inform the locals on the availability of DRT (as an alternative to fixed route services) and how to use these services. It is known that it takes time for people to change their travel habits. However, large numbers of new customers are trying the BRIDJ services each month. In particular, since month 2 of service in Region 6, BRIDJ has seen approx 30-60% growth in total passengers, each month. In general, it is found that the customers using these services are engaged and are willing to provide well considered feedback.

5.3 Future investigations

5.3.1 Identify local service inefficiencies

Most local and feeder fixed route services are cost inefficient but are currently required for coverage reasons (to date there has been no better solution). This follows the NSW Service Planning Guidelines (NSW Government, 2006) which provides guidance on designing a hierarchy of routes to obtain service frequency, network simplicity, spatial coverage and route directness. Regarding spatial coverage, the guidelines specified that 90% of households should be within 400 m of a rail line and/or a Regional or District bus route during day time and 800 m at night. As a result, feeder buses are prevalent across the NSW network. Effort should be put into identifying those fixed route services that should be truncated or completely converted into better and cheaper DRT services, based on patronage / quality of service (indeed, if a DRT service becomes so popular, it could ultimately be converted into a fixed route service). In this regard, spatial analytics of smart-card data have a huge potential in identifying areas/routes where DRT can replace fixed routes to obtain cost-efficiency and/or service improvement.

This will allow the larger vehicles to be recycled to the trunk corridors (fixed route services generally belong on trunk corridors and a need to replace these trunk corridor services with DRT is unlikely to arise). These extra resources (i.e., the reallocated resources) on the trunk corridors can help turn those services into higher frequency 'turn-up-and-go' / headway managed services. Having a mix of fleet between suburban feeder networks and trunk corridors can be beneficial in a number of ways; (1) DRT services typically use smaller capacity vehicles which are cheaper to run and have less impact on local roads, (2) DRT vehicles are able to more nimbly navigate more complex suburban road structures that are often narrow (pedestrians generally feel safer on their streets with smaller vehicles), and (3) DRT vehicles produce less noise and air pollution compared to a large buses, and are more suitable for electric vehicle technologies (compared to large buses that are not able to operate as long without recharging).

It is worth noting that a given service does not necessarily have to be either demand-responsive or fixed route – for instance, some of BRIDJ's DRT services operating outside Region 6 are partly complemented by a peak time fixed route service which caters for large peak loads of school children. Service delivery of DRT can be categorised under a spectrum where fully fixed routes are at one end and single person point to point at another. While the current software BRIDJ relies on is on demand, it is closer to the fixed route end of the spectrum than the point to point end. BRIDJ is hoping to further enhance the existing software to enable them to seamlessly change their operations across this spectrum, depending on various service objectives, demand settings, times of day and locations.

5.3.2 Identify barriers to use

Cost of service remains the main barrier to using DRT services by potential customers. While not the focus of this paper, a key insight that can be gained from the BRIDJ on-demand trials in Rose Bay. The one-way fare experienced by a customer using the Rose Bay service is \$9.21 (\$3.20 for the BRIDJ trip + \$6.01 for the onward ferry trip to CBD) – which is around 2.5 times higher than the \$3.66 fare on the 333 bus route (from Bondi to CBD). If BRIDJ services were more competitive with bus route 333 from a fare perspective, then more customers may choose the on-demand services, thus helping overcrowding issues on the 333 buses at peak periods and delivering more revenue by increasing patronage on the currently under-utilised ferries.

This high cost is creating a barrier to use for many customers, despite the possible travel times savings and the superior travel experience offered by BRIDJ services. In particular, customers find it difficult to regularly justify a higher fare for the DRT service, when it competes directly with the existing fixed route services. Feedback from customers indicate that the higher fare is limiting them becoming regular/every day users, and instead tend to use it on an ad-hoc or semi-regular basis. While over 90% of the customers in Region 6 (>70% in Rose Bay) pay for the DRT services by Opal card, they are not provided with added Opal benefits such as mode transfer discounts or weekly caps.

Provision of transfer discounts to the customers is essential, for on-demand service such as BRIDJ's Region 6, since the primary purpose of these services is to feed customers onto the trunk public transport system. Lack of transfer discounts is creating a perverse disincentive to higher usage levels and makes other options relatively more attractive despite the travel time savings enabled by the on-demand services.

It is also worth noting the role of infrastructure in attracting new DRT users. Lack of encouraging infrastructure is particularly problematic when asking the current PT users to change their travel behaviour. For instance, better interchanges can make two seat journeys much quicker and attractive. Therefore, more holistic efforts need to occur to facilitate the behavioural change of the travellers over time.

5.3.3 Understanding the right fare structure

Rather than simply trying to justify a higher fare, it is imperative to incentivise greater use of DRT in order to get people off private vehicles. For instance, this could mean offering a better (or more personalised) service to increase usage (note that current regulations do not allow charging a higher fare for a better service in Region 6 although this may change in the future when DRT is more popular). The idea here is to drive the efficiency/reduce subsidies per passenger, required in the public transport network. Setting fares too high is therefore counterproductive to this effort (transport by private vehicles, without congestion charges, is already too attractive from a cost perspective).

TfNSW has recently made an interesting finding in relation to fares. When the customers were asked how they perceived the 'value' of the on-demand transport fares at $3.20 (the regular flat fare for Region 6), the answers indicated that they saw good value. However, upon deeper analysis, TfNSW realised that they have been posing the wrong question. Customers initially saw value in the on-demand transport fares since they were comparing this fare to taxi and ridesharing services. However, as the customers realised that the level of service offered by DRT is not necessarily as personalised as a taxi or an Uber, they started to compare the value relative to other competing public transport services. As a result, the answers changed to suggest that the on-demand transport fares were too high to use every day and as such the use has been more ad-hoc based on convenience.

5.3.4 Establish the right Key Performance Indicators for assessing DRT

A complete rethinking is required around the Key Performance Indicators (KPIs) when assessing DRT services. Firstly, these KPIs should consider the function the DRT services are seeking to fulfil. In fact, many private sector operators do not view DRT services as actually commercial. Many are provided at the cost of high "shareholder subsidies" in the interests of proving a new transport concept or gaining overwhelming market share (e.g., Chariot, Uber, Via). Services such as BRIDJ are delivered as part of a suite of services that some operators believe is necessary to meet the needs of a decentralised, affluent city. For example, BRIDJ was not considered a success in their Boston operations because it was trying to run a profitable service out of its fares without appreciating the benefits it produced in a broader context or the excellent technology it had developed over time.

Secondly, it is necessary to understand and quantify what the intangibles such as reliability / on-time running, and convenience really mean to the customers in a dynamic world without timetables. For example, is on-time running better measured as a comparison of the actual pick-up / drop-off times versus those times that BRIDJ inform the customers when they book via the app? How is this influenced if the customer is provided real-time updates based on extant traffic conditions or new bookings?

Finally, the right question to be asking may not be *how much could be charged from a customer for a DRT service*. BRIDJ aims to lower the cost of running a public transport network for cities and operators through more efficient routing, matching and reallocation of assets. Given these aims, the more interesting question is *how much do cities save using a DRT service (in particular, we would want to know in benefit cost terms the gain in net social benefit per dollar of subsidy outlay).* This includes easy to measure operational costs, harder to measure network benefits and much harder to measure benefits such as less crowding on the roads, less infrastructure and parking costs, etc.

5.3.5 Investigate the interaction of DRT with the existing public transport system

It is important to investigate how the DRT services interact with the existing public transport system. Ideally the DRT services should complement the existing PT system, as opposed to providing redundant services. Some key questions that should be addressed in this regard are;

- How do fixed route and DRT timetables interact with each other? Are connecting journeys handled seamlessly between the two modes of transport? Should timetables be integrated so customers are able to easily plan a connecting journey? Should they be integrated so there is less of a wait between connecting services?
- What extra savings are unlocked by using DRT in part of the network? What additional benefits could be gained by reallocating vehicles and drivers to different parts of the network in addition to savings that could be made using DRT in a zone?
- Do increased options for commuters and increased patronage on DRT services unlock the extra demand on fixed route PT services?
- What is the impact of having different fare structures for the different services? Can fare structures and payments be integrated?

Another important aspect that needs to be considered is the impact of DRT operations on general traffic. A study by the PTV Group suggested that pick up and drop off activities taking place on roads can have significant negative impacts on vehicle flows, leading to increased congestion unless dedicated kerbside laybacks are provided (ITF OECD, 2018). Therefore, provision of satisfactory infrastructure remains a key issue when implementing DRT services.

6. Conclusions

This paper has presented insights gained from BRIDJ operations in Inner West Sydney, since its commencement in July 2018. It is evident that DRT can play a number of roles in the general public transport network, including (1) peak feeder function, where the DRT services feed the trunk PT services, (2) connection function, where DRT is seen as a local connection service particularly during inter-peak periods, and (3) coverage function, especially in lower density areas which require some levels of service – in such cases, DRT can often cover greater areas and still satisfy the real-time demands more effectively. When implemented effectively as a peak feeder, DRT can be used as a tool to unlock broader fixed route network enhancements, as the regular local buses can be reallocated to the trunk corridors and be operated as higher frequency, headway managed services. DRT operations in Region 6 could eventually find some routes and timings that are popular among the customers, leading the operators to implement these services more frequently, or even permanently thus similar to regular services. However, unlike the typical supply focussed regular bus services, these new routes will be more evidence based and demand focussed.

Several barriers to the use of DRT were identified. In particular, feedback from customers indicates that the higher fare is limiting them becoming regular/every day users, and instead tend to use it on an ad-hoc or semi-regular basis. The higher fares are a result of the current DRT services in Region 6 not being provided with Opal benefits such as mode transfer discounts or weekly caps. Lack of transport discounts in particular, makes other transport options relatively more attractive despite the potential travel time savings enabled by DRT. Therefore, while DRT has great potential to link those in less connected areas with public transport hubs thus facilitating a modal shift away from private vehicles, they need to be affordable and well regulated. In near future, DRT services will likely be integrated into MaaS applications, which could provide immense benefits in terms of sustainable travel and the effective utilisation of road network capacity.

7. References

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