

Why most DRT/Micro-Transits fail – what the survivors tell us about progress

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Micro-transit; DRT; Demand Responsive Transit

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ABSTRACT

Media often reports demand responsive transit (DRT) and ‘micro-transit’ (MT) as ‘re-inventing’ conventional fixed route transit but rarely report financial data on DRT/MT performance or note their high failure rates.

This paper reviews DRT/MT systems performance with particular focus on failure rates. Results show DRT is very failure prone ; 50% last less than 7 years, 40% last less than 3 years, and about a quarter fail within 2 years. In the UK, 67% of DRTs have failed, and in Australasia, 54%. Results identify and explore three distinct phases of global DRT development since the 1970s; recent MT are most failure prone (50% fail within 2 years).

Results show a strong link between failure and higher costs. Specialist DRT services for disabled people were relatively cheaper while MT was found to have higher and increasing costs. Results imply simpler (e.g., many-to-few or route deviation) operations had lower failure rates compared to more complex many-to-many services.

Conclusions suggests that despite 40 years of experience, the high failure rate of DRTs suggest they are still a high cost, experimental, uncertain and unreliable solution for cities. The paper explores policy implications of these findings and areas for future research.

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1. Introduction

Every so often, the desire for convenient, flexible, and individualised public transport reincarnates in some form or another; called Dial-a-Bus in the 80's, then Demand Responsive Transport, and now there is 'Micro-transit' in the digital millennium. In each iteration, inventors, entrepreneurs, and 'disruptors' present their new system, often capturing the public imagination and reigniting the debate about whether society should abandon the "horrid" buses and trains of yesteryear and embrace this latest transport revolution. Is it a transport revolution, or is it merely hype driven by investment profiteers?

Going back over 40 years, the concept of Demand Responsive Transport (DRT) is not new by any means. Yet today there is a resurgence for DRT across media platforms. News, blogs, and TED-talks frequently feature an intellectual discussion on the 'future of transport', often invoking vocabulary like *mobility*, *flexibility*, or other words containing the suffix of '-ility'. The expertly marketed start-ups claim that transport can be 'optimised' by leveraging mobile technology that has matured over the last decade, allowing travellers to supplement their personal automobile transport with DRT. However, these services are fundamentally an app-based 'dial-a-ride' with weak driver contracts and a computerised dispatcher. A major contractual and technical achievement, perhaps; but is it a revolution? or just another version of dial-a-ride which has had very limited success in practice?

Behind the 'hype' and media coverage of 'micro-transit' is over 30 years of academic research into demand responsive transit (Brake J et al., 2006, Mageean and Nelson, 2003, Ambrosino et al., 2003). This research has explored new ways to operate and design flexible transport services as a means to encourage progressive development of the sector. What this research has not done is spend much time understanding failure of DRT type services. This is understandable, as researchers interested in this sector wish to understand and encourage success. Almost universally researchers in this field are also 'advocates' for continued development of DRT and flexible transport services. This has also influenced their lack of interest in DRT failure. This is a pity since failure can be revealing and it is also a major trend in the sector. Even today in the latest 'micro-transit' revolution there have been some spectacular failures, such as Bridj which shuttered its U.S. operations in 2017 after averaging a stunning US\$1,000 (A\$1,400) subsidy per trip (Marshall, 2017, Schmitt, 2018); and Chariot which recently announced the joyride is over (Marshall, 2019). However, from the founder's perspective they are not seen as failures at all, as both of these schemes were purchased for many millions of dollars by Ford and the Transit Systems Group long before their eventual collapse in U.S. markets.

This paper explores the failure of the group of public transport 'alternative' services which are known as Demand Responsive Transit (DRT), dial-a-bus or micro-transit; collectively we call these services DRT. The research explores what we know about failure and success from the research literature. It then explores success and failure factors as experienced in a collated database of DRT schemes from over the last 40 years of research.

The paper is structured as follows; the next section outlines research literature on DRT service types and what we know about DRT failure and success factors. The research methodology is then outlined. Results then describe what we have learned about the length of historical and contemporary DRT schemes as well as what we know about factors influencing their failure

and longevity. The paper concludes with a discussion of the implication of key findings for practice and areas for future research.

2. Research Context

DRT Definitions

Engels and Ambrosino (2004) see DRT as being a 'flexible, intermediate', transit mode which 'fills the gap' between individual taxi type services and scheduled fixed-route conventional transit (see Figure 1).

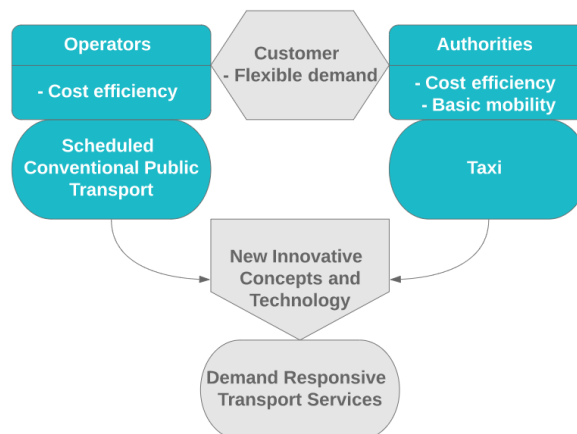


Figure 1: DRT Gap Filling (Engels and Ambrosino, 2004)

A number of typologies for DRT service have been developed to describe the features and implementation of DRT, and how these relate to conventional modes. Enoch et al. (2004) outlines a basic application framework for DRT as:

- **Interchange DRT** – providing feeder links to conventional public transport.
- **Network DRT** – enhancing public transport either by providing additional services, or by replacing uneconomic services in a particular place or time.
- **Destination-Specific DRT** – a specialist form of network DRT that serves particular destinations such as airports or employment locations.
- **Substitute DRT** – DRT totally replaced conventional transport, resulting in a reinvention of public transport.

In general, DRT has evolved to become largely an umbrella term in industry used for any public transport service that provides flexibility either spatially and/or temporally. At one extreme, DRT can be effectively a publicly operated taxi service, providing fully flexible service wherever and whenever the user requests. At the other end of the spectrum, demand responsive may simply be a stop requested bus service. In between exists a plethora of possible perturbations (e.g., route deviation, ride-pooling, etc.) catering to users with some level of compromise.

This is a theme taken up by D'Este et al. (1994) by constructing a rudimentary space-time model which describes transit service types within the two dimensions of:

- Service frequency – which can be either instant or slow (long headways); and
- Service coverage – which can be either full, and hence easy to access, or minimal with difficult access.

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In the D'Este et al. (1994) model in Figure 2, DRT occupies the space between the extremes. Implying there is a compromise between the “instant frequency” and “full coverage/access” of the automobile, and the cost effectiveness of public transport.

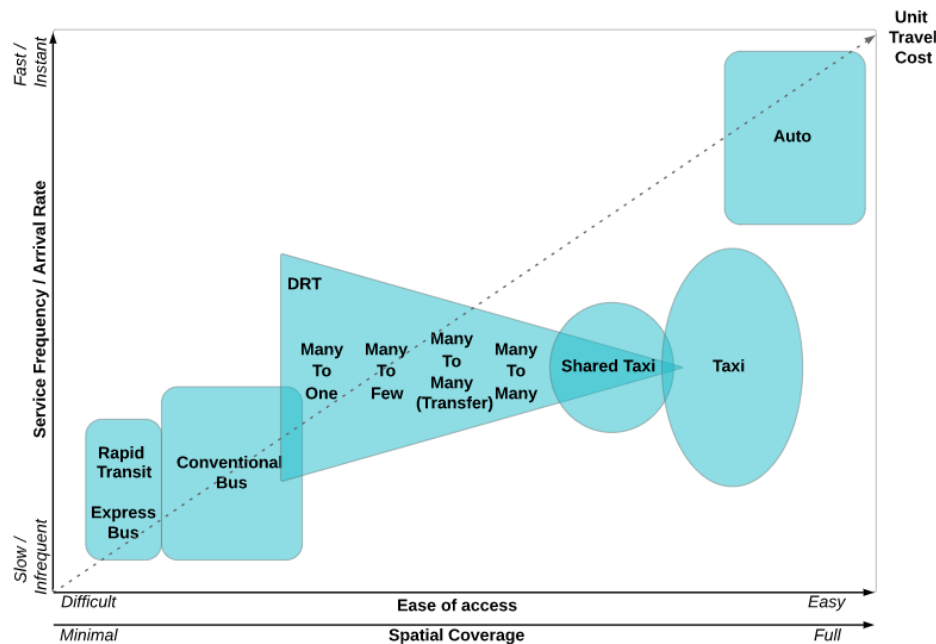


Figure 2: DRT in the Context of Frequency and Coverage (based on D'Este et al., 1994)

The model also segregates DRT services into a series of sub-groups related to scheduling and operational configuration which have varying performance on these scales. These include:

- **Many-to-One Services** – where patronage is concentrated at one of the two trip ends considerably reducing the complexity of operations.
- **Many-to-Few Services** – where more than a single location at one trip end, but few enough to remain manageable.
- **Many-to-many (Transfer)** – where patrons can travel to or from any location, but the system may require patrons to transfer vehicles to complete their journey.
- **Many-to-Many** – covering all trip origins and destinations with a direct service.
- **Shared Taxis (Often called Multi-Hire Taxi or ride-pooling)** – conventional taxis except several people can use the same vehicle and it may involve route deviation.

The horizontally oriented DRT region of the model suggests that network coverage increases with the complexity of origin-destination configurations. Meaning that a many-to-many model affords higher spatial coverage than a many-to-one model. However, the model optimistically shows all DRT operations as having similar service frequencies.

Success and Failure Factors

A study by Enoch et al. (2004) recognised that many DRT services struggle to survive and identified four typical service performance outcome levels:

1. **Commercially viable DRT** – These are services that are either profitable, or operate within a commercial context (e.g. temporary losses are accepted as a service is built up or a loss-making service is compensated by its positive financial effects on a service network as a whole). The study identified that there are very few of these services.

2. **Acceptable subsidy DRT** – This is where DRT requires only the same (or less) subsidy than other comparable tendered services. Again the study suggested there were very few of these types of services.
3. **Justifiable higher subsidy DRT** – This is where a subsidy above that comparable to tendered/alternative services can be justified. This may be due to the operational area (e.g., rural areas), social necessity (e.g., accessible transit), or that DRT is replacing inherently even more expensive transport, or because it is yielding significant cross-sector benefits. This was identified to be the most common type of DRT service.
4. **Financially unsustainable DRT** – These may be demonstration and trial projects or other services whose losses remain very high and where services are eventually withdrawn as a result of high costs. The study again noted that there are many in this category.

Behind this research is critical concern about the cost performance of DRT systems. Enoch et al. (2004) benchmarked a cost per trip threshold of £2.00 (£3.05 and A\$5.63 in 2019 values) as what is considered *acceptable subsidy*, relative to subsidies for fixed-route public transport. Enoch et al. (2004) also notes that as a result, fares for DRT services tend to be more expensive than traditional fixed-route public transport at £7-15 (A\$13-28), but can be cheaper than taxis and non-emergency medical transport at £15-30 (A\$28-56), adjusted for inflation to 2019. These findings match exactly the concerns older research had with failure of dial-a-ride type services in the 1970s;

“Most of the services that have stopped have done so because of the high costs in relation to their patronage”

Oxley (1979)

“Increased mobility is rather intangible when compared to the harsh reality of deficits on a balance sheet”

Transport Canada (1978).

Enoch et al (2004) also explored factors which affected failures of selected DRT trials and also explored those which had been successful. From this the following key factors were identified from this research:

- Keep it Simple – avoid overly complex DRT system unless you have confidence it can be paid for and will work effectively.
- Ensure DRT Operator Buy-in and Confidence with alternative services.
- Ensure High Profile Marketing of the Concept – since users often do not understand how to use DRTs.
- Raise Fares to Pay for Higher Quality Service.
- Target Workable Catchments – under-developed areas and overly circuitous street structures should be avoided since this can increase costs.

A major international development making ‘justifiably higher subsidies’ more palatable has been the policy imperative in some jurisdictions to fund specialist transport services for disabled people. In the USA, this was manifested in the Americans with Disability Act (1990) which created the paratransit sector; an entirely new public transport for the bespoke use of persons with disability. In the UK in the 1990’s, bus deregulation outside of London had a similar impact. Socially focussed conventional bus services were widely withdrawn as

subsidies were reduced and redirected to community transport services; including dial-a-ride type services to fill the gaps that were left. In the USA there are over 1,500 paratransit services where the average cost of a paratransit trip in 2010 (adjusted to 2019 dollars) was US\$34.34 (A\$48.08). This compares to just \$9.55 (A\$13.37) for a fixed-route trip (United States Government Accountability Office, 2012).

Of course, fixed cost per passenger is almost always higher due to the economies of scale afforded by the higher capacity and operational efficiency of fixed-route transport. However, Volinski (2019) points out that in certain cases where high costs are unavoidable (e.g., paratransit or low-density rural regions), DRT can be justified when the *cost per hour* is less than with a fixed-route service due to the use of contractors and smaller vehicles.

Enoch et al. (2004) also introduces the argument that the cost of DRT may be reduced as the cost of technology and/or labour are reduced over time. This argument has garnered more support in recent years with the proliferation of smartphones and mobile communications over the last decade. Indeed, these suggestions provide some support for the 'micro-transit' advocates who suggest that DRT type services over the last decade have benefited from new technology to make these systems more effective and sustainable. The key question remains; is this true?

There have been a number of European Union studies focussing on success factors for mainly rural DRT service (Commission for Integrated Transport, 2008) but also some consideration of urban services (Wright et al., 2011). Key suggestions for success were to:

- (for rural services) leverage scale economies by operating larger, even nation-wide, schemes,
- Implement approaches to reduce costs and increase revenues via farebox,
- Adopt smaller buses and taxis into services (which can reduce costs),
- Adopt new technologies which can reduce costs and increase utilisation of resources, and
- Ensure good marketing to assist users understand less conventional (and new services).

In the Australasian context a project exploring the viability of DRT type systems for deployment in Christchurch New Zealand reviewed the performance of over 20 DRT systems from around the world (Travers Morgan, 1990). This suggested the following key success factors in an Australasian context:

- Target areas where conventional Public Transport Service Levels are low and hence an alternative is needed.
- Use smaller buses/taxi type vehicles to reduce costs.
- Target low demand times (night, weekend and interpeak) where conventional public transport buses might be deployed at marginal (low) cost.
- Target niche markets (e.g. persons with disabilities) where higher subsidies will be justified.
- Where labour arrangements can be low cost and flexible (such as the volunteer drivers used in the UK Community Transport sector).

- Where trip demands are focussed and concentrated; many-to-one services are easier and cheaper to operate; many-to-many services over a wider area are more expensive and difficult to manage.

Taking all the above studies together, some key strategic suggestions for success (or failure) can be synthesised from these findings. These are to be adopted as key research questions which will be explored in the DRT system analysis in the next section. The success/failure factors and key research questions are:

- **High Costs;** are higher cost DRT systems less successful? are low cost systems more successful?
- **Justifiable Subsidies;** are DRT systems focussed on niche markets more successful because subsidies are acceptable for these markets?
- **New Technology and Costs;** are newer DRT systems cheaper and hence more successful?
- **Keep It Simple;** are DRT systems focussed on simpler designs (e.g., many-to-one rather than many-to-many) more successful? Or conversely; are larger many-to-many full-scale DRT systems more successful?

These issues will be explored in the analysis of DRT systems adopting the database developed for the research.

3. Methodology – The DRT System Database

Research was conducted in two basic steps. First, data collection of all possibly identifiable DRT systems found in literature, media, and industry. Second, to identify trends and patterns using this database of DRT systems.

Data collection

Research sought to develop a database of DRT systems, ideally including a balanced and representative sample of both successful and failed systems over the last 30-40 years. In addition, it was hoped to identify the features of DRT systems which might explain success and failure; notably the costs of operating the system, the type of service (public or specialist paratransit/community transit service), the type of operation (many-to-many/many-to-one).

The aim of obtaining a representative sample of successful and failed systems was problematic since it is common that failed services are quickly forgotten; rarely remembered and never advertised over the long term. Successful systems however are likely to have available information since they need to advertise to users. Hence there is danger of sample bias towards more successful systems since information on these is more readily available.

Data was sought on DRT's in any geographical context for the purposes of understanding patterns of diverse systems'. Again this was problematic because only DRT systems in selected geographies had data available.

All sourced DRT systems which were findable were adopted; this includes:

- Details on 24 DRT systems from around the world were recorded in a consultancy database developed in 1990 (Travers Morgan, 1990); these were checked to see if they are still operating. This source also identified individual operating conditions and

operating costs which could be adjusted to 2019 Australian dollars in real terms using currency and inflation factors.

- A fairly recent US DRT study (Volinski, 2019) identified an additional 14 DRT systems with their key characteristics and costs. Again, it was possible to check start and end dates for any of these systems using web searchers.
- A range of web searches and a review of other select studies (e.g. Enoch et al., 2004) was able to identify an additional 86 other DRT systems throughout the 30-40 year timeframe of interest. However, only the approximate start-up and end dates could be identified for 70 of which, and for the remainder only the mere existence could be confirmed from a web search or published material.

This search approach was difficult and time consuming, the results were also far from perfect from a sampling viewpoint. However, in the end a database of some 120 DRT systems from 19 countries was established. As mentioned, operations and cost performance data were not available for all these systems, but of these, a reasonable sample of 33 DRT systems with operation and cost attributes was achieved. Attachment A presents raw data for the database developed in the research which was used to explore the research questions identified earlier.

Analysis

As opposed to a narrow and in-depth analysis that focused on a handful of DRT systems where comprehensive data exists; this analysis took a broader approach in analysing as many DRT systems in as many places and times as possible, despite lacking detailed attributes in each. Analysis sought to understand aggregate overall patterns and trends in DRT performance on an industry wide scale using the DRT's in the database. This analysis is cut into four aspects.

- **Failure rates:** Although the majority of identified DRT systems in the database only possess the thin attributes of start-up/end years, this still provides valuable aggregated insight. The overall rate of failure of DRT systems can be determined by aggregating the number of all active and inactive DRT systems by location (e.g., country or region) or time (i.e., year). This provides a broad perspective of how successful DRT systems are overall, and where/when this occurs.
- **Temporal analysis:** Further analysis of the start-up and end years can reveal temporal trends and patterns that have occurred macroscopically. It is possible that there are particular periods where patterns of boom and bust may emerge. If so, there may be larger economic and political factors at play beyond localised system performance.
- **Cost and operational analysis:** Using the subset of DRT systems in the data with sufficient cost and operational attributes, further analysis can help reveal overall factors associated with failure (e.g., high costs, simple operation, etc.).

Whenever possible, simple statistical tests are utilised to provide a robust and statistically significant answer. However, broader and more contextual analysis is often necessary to glean useful insights and failure factors from specific instances.

4. Results

Analysis explored the following topic areas using the database developed in the research:

- i. DRT Success and Failure Patterns

- ii. The (Half) Life of DRT schemes
- iii. DRT Costs - Success and Failure
- iv. DRT Justifiable Subsidies and Specialist Services
- v. DRT New Technologies & Costs – Success and Failure
- vi. DRT Operating Types - Success and Failure

i. DRT Success and Failure Patterns

Table 1 shows some summary statistics of DRT services in terms of active and inactive services for the whole analysis period (1970-2019) and also by world region. This indicates that:

- Overall 48% of DRTs have failed over this period.
- A substantially higher share has failed in the UK (67%) than in Europe (23%) where the failure rate is substantially lower than all other world regions.
- Australasia has a 54% failure rate, the second highest in the world after the UK.
- The USA/Canada has a 50% failure rate.

Table 1: Active, Failed DRT Service by Region (1970-2019)

Region	Active	Inactive	Total	% Active	% Inactive
USA/Canada	17	17	34	50%	50%
UK	12	24	36	33%	67%
AU/NZ	6	7	13	46%	54%
Europe	24	7	31	77%	23%
Total	59	55	114	52%	48%

While data collection for these DRT services is far from random in that the data are compiled from previous available studies largely focussing on operating DRTs at the time, the data suggests a very high failure rate for DRT services despite this bias. Indeed, it is likely that in truth, failure rates might be even higher since it is difficult to identify failed services, inadvertently omitting them from the database.

Figure 3 shows a frequency distribution over time of DRT Start-ups and Failures over the 40 or so years of the analysis.

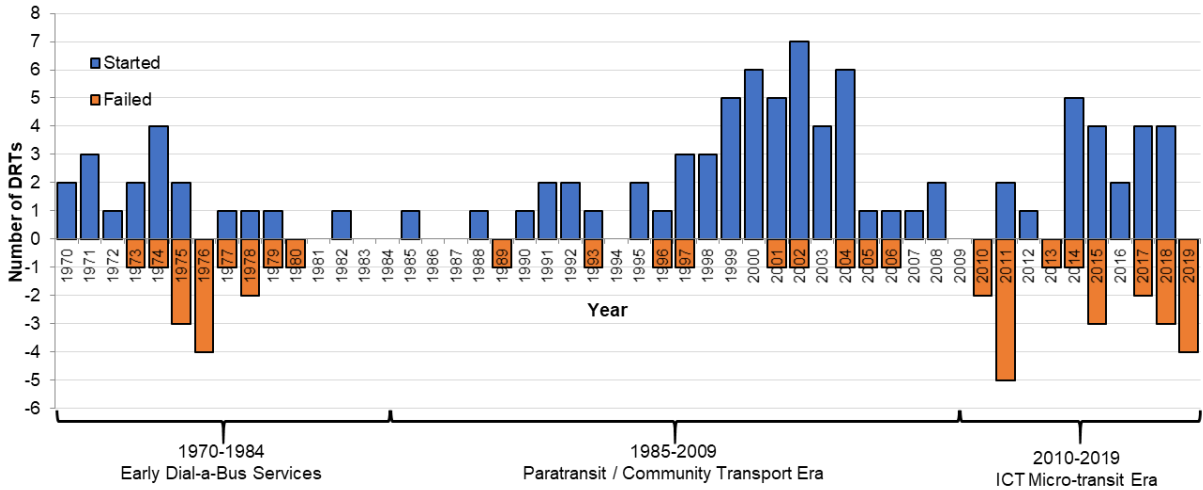


Figure 3: Frequency Distribution of DRT Start-ups and Failures

Three distinct periods are suggested by the pattern of DRT development in Figure 3:

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- Early DRT Dial-a-Bus Type Development (1970-1984) – When some of the first attempts to run demand responsive services were developed. This period has less start-ups per year than any era; but also, relatively more failures.
- Paratransit/Community Transport DRT Era (1985-2009) – When as a result of the Americans with Disability Act (ADA) legislation, the US paratransit services were developed; and at the same time in the UK, bus deregulation outside London had resulted in significant investment in special needs style DRTs to fill gaps in withdrawn social bus services. DRT’s in this era were heavily subsidised as charging fares is problematic for a low and no income social needs based ridership. Also, many of these services had volunteer drivers and were operated as charity based non-profit services. This period has more start-ups than any era, notably towards the end of the period (1997 to 2004); interestingly this era has less failures.
- ICT Tech Micro-Transit DRTs (2010-2019) – When new technologies are being deployed for modern ‘micro-transit’ based DRTs. This period has less start-ups per year than the Paratransit/Community Transport Era but much more than the early dial a bus era. Interestingly this era has more failures than prior eras both in total and on an annual basis.

ii. The (Half) Life of DRT schemes

Figure 4 shows the distribution of DRT start year and finish year for schemes in the analysis; schemes below the line (red) have failed, schemes above the line have continued.

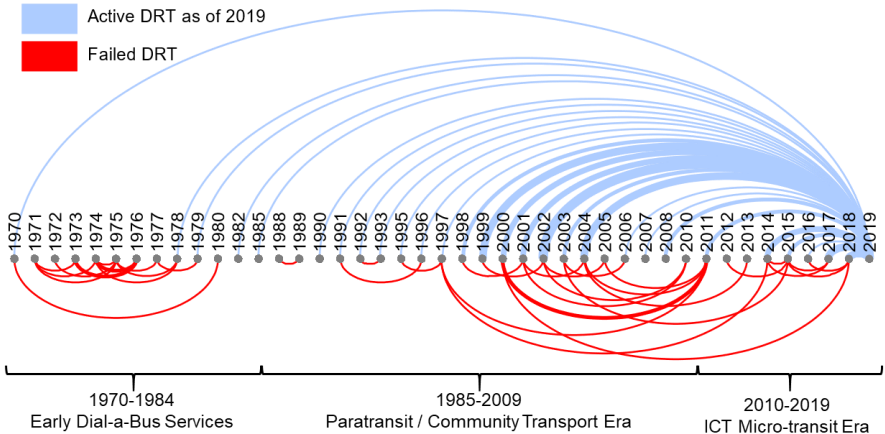


Figure 4: DRT Lifespan – Start-up and Failure Years

This suggests that many of the original 1970-1984 era DRTs failed and very few still survive; indeed 81% of DRTs in this ERA have failed. The life spans of the Paratransit/Community Transport era DRTs are longer in the Figure 4 results; interestingly a higher share of these DRTs failed during the ICT Tech Transit DRT era. On average 58% of the Paratransit/Community Transport era DRTs are still active suggesting this was the most successful era for DRT survival. Some 45% of the ICT Tech Micro Transit era DRTs have failed, a comparatively high number given this is the youngest era and many of these newer DRTs have not yet run long enough to fail.

Figure 5 presents a lifespan analysis of DRTs for all the systems analysed and also for the three Eras identified in Figure 3. DRT lifespan is explored using its distribution amongst DRTs; the 50th percentile or ‘half-life’ is adopted as a measure of lifespan. Figure 5 indicates that:

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- 50% of all DRT last less than 7 years; however the distribution is highly skewed; 40% of DRTs last 3 years or less; about a quarter fail before 2 years is up.
- By DRT era a very distinct picture emerges; the life span of the Early DRT Dial-a-Bus Type Development (1970-1984) and The Paratransit/Community Transport DRT Era (1985-2009) is extremely short and fleeting; 50% of these DRTs fail within 2 years; interestingly both these eras have very similar failure profiles; despite the hope expressed for modern technology with current micro-transit development; the failure profile of this era is very similar to the first DRT dial-a-bus era
- The great standout ‘survivor’ of the temporal lifespan analysis in Figure 5 are the Paratransit/Community Transport Era DRTs (1985-2009); 70% of these DRTs have a lifespan of 17 years or less. Clearly these mid-era DRTs have survived considerably longer than all the other DRT types analysed.

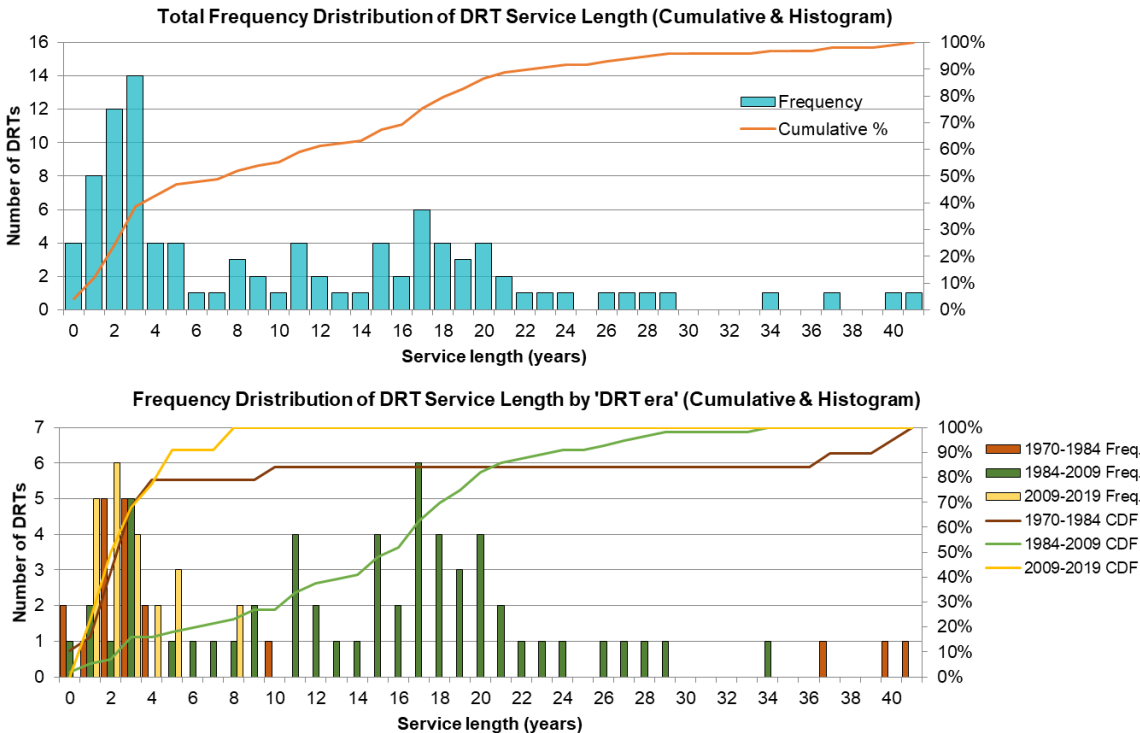


Figure 5: A Frequency Distribution of DRT Lifespan – Total (above) and by Era (below)

iii. DRT Costs – Success and Failure

Figure 6 illustrates the distribution of DRT costs per vehicle-hour (\$Aust 2019) by service length. This tells a compelling story that lower cost services last much longer than short ones. In fact, it would appear that DRT service life is exponentially decreased as cost increases. To verify this trend, an exponential model was fit to the data, yielding a good fit result with an R² of 0.38.

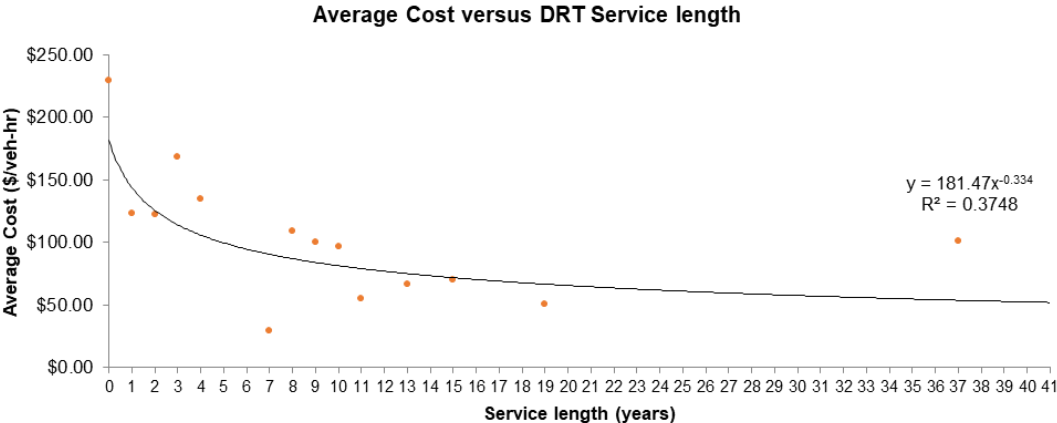


Figure 6: DRT Operating Cost by Lifespan

Table 2 shows a further exploration of the links between cost performance and DRT system failure. Active services are split into long and short groups to account for young systems which have just started and may bias the analysis. The variables are split into high/low cost and short/long life using the median split in each case, respectively; for example, a “high cost” is a system with a cost higher than the median of all systems.

Table 2: Low/High Cost DRTs by Active/Inactive Groups – Chi-squared test

Relative cost	Service life			Total	X ² test of independence	
	Active-short	Active-long	Inactive		Df	
Low	2	8	6	16	X ² statistic	0.058
High	1	2	14	17	p-value	0.029
Total	3	10	20	33		

A Chi-squared test on this table (95% confidence interval) show a statistically significant link between high costs and DRT failure; thus high cost DRTs tend to fail.

Figure 7 illustrates trends in DRT cost performance over time. This indicates that:

- There is a weak trend ($R^2= 0.11$) towards costs per vehicle hour declining over time. However there is much scatter in the data; for example an analysis starting in the year 2000 would suggest a growing trend in unit costs per vehicle km.
- There is a weak trend ($R^2= 0.06$) towards costs per passenger increasing over time.

The above result provided some support to the view that the third era DRTs, including micro-transit, are proving more cost effective, but as noted the contemporary trend (post 2000) is toward growth in costs per vehicle hour. The weak trend towards increasing costs per passenger suggests ridership effectiveness of DRTs (ridership per hour) is in decline; are modern DRTs carrying less passenger than historical DRTs?

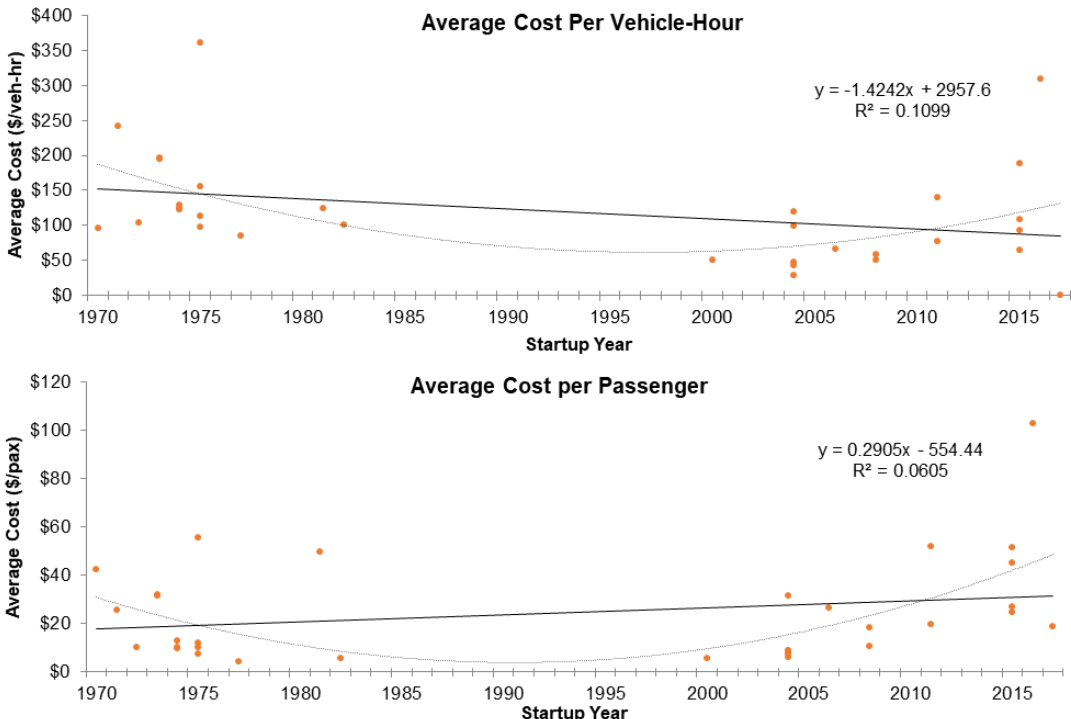


Figure 7: DRT Operating Cost Performance Trends – Cost/Vehicle Hour (top) and Costs/ Passenger (bottom)

iv. DRT Justifiable Subsidies and Specialist Services

We hypothesised that DRTs in the paratransit/community transit era would be high cost but may be considered to have ‘justifiable subsidies’, i.e. high subsidies which are acceptable because significant social needs are being addressed.

Figure 8 shows the average and distribution of DRT cost per vehicle hour by the 3 eras.

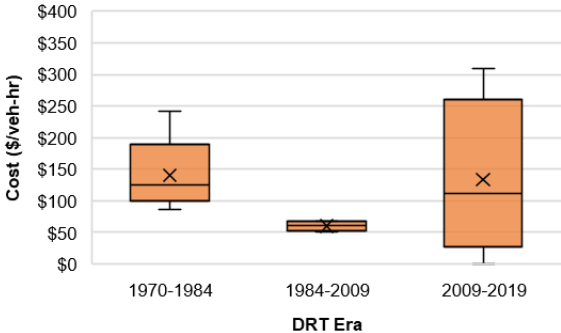


Figure 8: Average and Distribution of Operating Costs per vehicle-hour by era

The Paratransit/Community Transport Era (1984-2009) has a statistically significant difference (t-Test; 95% CI) in costs from the prior Early DRT Dial-a-Bus Type Era (1970-1984), but no significant difference among any others eras. The Paratransit/Community Transport Era also had a very narrow range of costs between systems compared to other eras. Average costs declined to \$63.07 from \$150.37, making costs in the Paratransit/Community Transport Era substantially lower not higher than both the older and newer eras.

The Paratransit/Community Transport Era (1984-2009) was the era most associated with specialist DRT systems for disabled passengers (Paratransit) and also acting as gap filling services in the UK as a result of bus deregulation. DRTs in this era also have the longest

lifespans. We speculate that DRT costs in this area are impacted by the use of voluntary labour acting to substantially reduce costs. Their longevity may well be associated with social justification of the funding needed for DRTs of this type, but longevity is also justified on the basis of lower costs. As the analysis in Figure 6 illustrates; lower cost DRTs have longer lifespans. We must therefore conclude that the hypothesis that DRTs in the paratransit/community transit era would be high cost with ‘justifiable subsidies’ is not proven; costs appear relatively low given this analysis.

v. DRT New Technologies & Costs – Success and Failure

There is no solid evidence from this analysis that the current era DRTs based on new technology and including micro-transit have lower costs. Analysis in Figure 7 does suggest a weak trend towards improved cost effectiveness over time, but the contemporary trend (post 2000) is toward growth in costs per vehicle hour. It is possible this is influenced by long term increases in wages although our adjustment for inflation should go some way to counter-acting for this. What is clear is that any cost savings from the use of new technology are not acting to reduce overall costs. Furthermore, trend data suggests costs per passenger are increasing since 2000, implying that the ridership effectiveness of DRTs (ridership per hour) is in decline; are modern DRTs carry less passenger than historical DRTs?

Figure 8 also suggests that costs for the ICT Tech Micro-Transit DRTs (2010-2019) are generally higher than in previous eras; average costs per vehicle hour are \$101.39; about double those in the 1984-2009 era. The reason for this is difficult to speculate, but in many recent ‘micro-transit’ cases fuelled by private venture capital, a substantial amount of money is invested upfront in new customised vehicles, equipment, and employees; costs that are never recovered given low DRT ridership.

vi. DRT Operating Types - Success and Failure

Some of the research literature (see section 2) suggests that simpler DRT types (e.g. Many-to-one/few service) are likely to be more successful than complex many-to-many operations (Travers Morgan, 1990). However, other literature suggests larger many-to-many schemes might achieve economies of scale which enable lower costs and higher more successful schemes (Commission for Integrated Transport, 2008). To explore this issue, DRT schemes where the operating scheme was known were isolated and active/inactive schemes tabulated. This included definition of the simpler ‘route deviation’ type services which operated on a fixed route and undertake short deviations on demand. Also ‘simplified operations’ where marginal costs of services were undertaken (operating off peak or in the evening).

Table 3 illustrates the analysis results of the 38 DRTs where factors could be determined.

Table 3: Active, Failed DRT Service by Region (1970-2019)

<i>Operating Types</i>	<i>Active</i>	<i>Inactive</i>	<i>Total</i>	<i>% Active</i>	<i>% Inactive</i>
<i>Route deviation</i>	4	7	11	36%	64%
<i>Many-to-One</i>	0	0	0	-	-
<i>Many-to-Few</i>	5	4	9	56%	44%
<i>Simplified operation (sum of above)</i>	9	11	20	45%	55%
<i>Many-to-Many</i>	5	13	18	28%	72%
<i>Total</i>	14	24	38	37%	63%

Table 3 indicates that:

- Many-to-many DRT (the more complex and larger scale DRT schemes) have the highest failure rate (72%) of the schemes where operating type could be defined. Based on this result; large scale and hence more complex systems may not be advisable.
- Many-to-few services (the simpler DRT type) has the lowest failure rate (44%).
- Route deviation and simplified DRT services demonstrated generally average failures rates so were not particularly better or worse performers compared other designs.

Overall this evidence supports the 'Keep it simple' mantra for DRT design.

5. Discussion and Conclusions

This paper explores the failure of Demand Responsive Transit (DRT) services using a literature review and collation of evidence of 120 DRT schemes over the last 40 years. Published research literature suggests high costs are a major failure factor for DRT systems, though specialist social-service based DRT systems (e.g. for disabled people) have been thought to warrant 'justifiable (high) subsidies'. It is suggested that modern improvements in ICT based technologies might make the latest form of DRTs (e.g., micro-transit) lower cost and thus more successful. Some research also supports the view that DRT simplified operations, such as many-to-one/many-to-few or route deviation, will be more successful; while other research supports the view that large scale comprehensive many-to-many schemes will generate scale economies making these schemes more successful.

Analysis has found DRT systems are indeed very failure prone with 50% of all DRT lasting less than 7 years, 40% of DRTs lasting 3 years or less, and about a quarter fail before 2 years. DRTs in the UK had the highest failure rate (64%) followed by Australasia (55%). It is possible that these failure rate estimates are skewed lower than in reality as many failed DRT systems cannot be identified. While failure rates are high this might be expected if these DRT's are seen as start-up companies; start-ups commonly fail quickly. Another perspective says DRT's have been around for 40 years; are they really new? From our perspective failure is endemic in the DRT/Micro transit industry but almost never acknowledged. This is an important issue which needs recognition; DRT/Microtransit can be better planned for resilience if failure rates are acknowledged and understood.

Three distinct phases of DRT development were identified and are consistent with the research literature: The Early DRT Dial-a-Bus Type Development (1970-1984), The Paratransit/Community Transport DRT Era (1985-2009), and The ICT Tech Micro-Transit DRTs (2010-2019). Interestingly, the first (1970-1984) and third (2010-2019) eras present very similar lifespan profiles (i.e., cumulative lifespan distribution in Figure 3) with extremely short and fleeting DRT systems; 70% of which failed within 3 years. For the 2010-2019 era; it could be argued that time to create longevity has not yet occurred. However the opposite is true; time for failure has not yet been allowed for. Despite this 70% have failed in the shorter time span which has passed for the 2010-2019 era micro-transits; this suggests their performance might be worst. Despite the hope expressed for modern technology with current micro-transit development, the low-tech DRTs in the Paratransit/Community Transport DRT Era (1985-2009) are far more long lasting; 70% of these DRTs have a lifespan of 17 years or less. Clearly these mid-era DRTs survive considerably longer than all the other DRT types analysed.

Cost analysis show a strong and definitive link between DRT failure and higher costs. However, results did not confirm the hypothesis that 'justifiable subsidies' for specialist DRT services for disabled people was a reason for the longevity of the Paratransit/Community Transport DRT

Era. To the contrary, DRT costs in this era appeared to be the lowest cost and most stable (i.e., with the least variation). Causality is unclear, but use of volunteers rather than paid drivers, as is often the case in the UK, is one possible explanation.

Results also found no link between lower costs and the modern ICT based services, such as micro-transit. Indeed, there is some evidence that costs per passenger are increasing over time (since 2000) suggesting more recent services are either more expensive to run or carry fewer passengers. Results did imply that simpler (e.g., many-to-few/one or route deviation) operations had lower failure rates compared to more comprehensive and complex many-to-many service types. It is possible that modern era DRT's have tended to adopt newer and more expensive DRT vehicles. The use of cheaper refurbishment of existing vehicles might be one way to reduce costs to achieve more cost effective DRT's into the future..

Overall this evidence suggests lower costs, specialist services and simpler service designs are a stronger context to develop successful DRT systems. The research has also revealed important long-term temporal trends with distinct eras where the context and influences on DRT service development were very different. This perspective better explains the performance of DRTs in each era and their rationale.

The methodology adopted in this research could be improved if a wider sample of DRT systems can be assembled including a more comprehensive and consistent collation of costing and operations data for each of these systems. The data collected is dependent on the published evidence available and may not represent an objective sample of systems over the last 40 years. The use of economic adjustment factors to create consistent valuations of system over time is also vulnerable to distortions of both costing method and inaccuracies due to both currency and inflationary movements over time.

To the authors knowledge this is the first paper to explore DRT and micro-transit failure performance across the industry. There is a clear and present need for analysis of this kind into the future. Research groups interested in DRT research should be developing a database of existing services to collate records of failure and success into the future.

While there is room to improve the methods adopted in this research the findings demonstrate that there is much value in understanding the failure of DRT systems. This should send a strong message to the DRT industry that it needs to better understand and document failed systems since they are important pointers to success. It is also important that governments under pressure for solutions to growing transport problems are not 'hoodwinked' by the allure of the new technology DRT 'hype'. The fact is that 1 in 2 DRTs fail and the costs of DRT are high and growing. This suggests the field is still highly experimental and unreliable. Until we better understand the ingredients to success, DRT systems will remain an experimental and unreliable solution to growing urban transport problem.

References

AMBROSINO, G., NELSON, J. & ROMANAZZO, M. 2003. *Demand Responsive Transport Services: Towards the Flexible Mobility Agency*, ENEA Rome, 55-74., Rome, ENEA Rome.

- BRAKE J, MULLEY C & NELSON J 2006. *Good Practice Guide for Demand Responsive Transport Services using Telematics*; , University of Newcastle upon Tyne, United Kingdom.
- COMMISSION FOR INTEGRATED TRANSPORT 2008. A New Approach to Rural Public Transport. . Commission for Integrated Transport UK.
- D'ESTE, G., TAYLOR, M. A. P. & RADBONE, I. G. Demand Responsive Public Transport for Australia: The TradeOffs. 1994 1994. 207-222.
- ENGELS, D. & AMBROSINO, G. 2004. Service Typologies and scenarios. Rome.
- ENOCH, M., POTTER, S., PARKHURST, G. & SMITH, M. 2004. INTERMODE: Innovations in Demand Responsive Transport. Department for Transport and Greater Manchester Passenger Transport Executive.
- MAGEEAN, J. & NELSON, J. 2003. The evaluation of demand responsive transport services in Europe. *Journal of Transport Geography*, Volume 11, Issue 4, , Pages 255-270.
- MARSHALL, A. 2017. How a Failed Experiment Could Still be the Future of Public Transit. *Wired*, March 6, 2017.
- MARSHALL, A. 2019. Ford Axes Its Chariot Shuttles, Proves Mobility is Hard. *Wired*, January 10, 2019.
- SCHMITT, A. 2018. The Story of "Micro Transit" Is Consistent, Dismal Failuer. *Streetsblog USA*, 26/06/2019.
- TRAVERS MORGAN 1990. Canterbury Dial a Bus Study – Final Report. Canterbury Regional Council December: Canterbury Regional Council December.
- UNITED STATES GOVERNMENT ACCOUNTABILITY OFFICE 2012. Demand Has Increased, but Little is Known about Compliance. Washington, D.C.
- VOLINSKI, J. 2019. *Microtransit or General Public Demand-Response Transit Services: State of the Practice*, Washington, D.C., Transportation Research Board.
- WRIGHT, S., UNIABDN, MASSON, B. & M.M.T.S 2011. FLIPPER Fleible Transport Services and ICT for Eco-Mobility in urban and rural European areas D(Good Practice Guide. *In: IVC, I. (ed.)*. European Union.

ATTACHMENT A

AGENCY	STATE	COUNTRY	OPERATION	FLEET SIZE	PAX PER VEH-HR	\$ PER VEH-HR	\$ PER PAX	START	END	
1	St Albans	VIC	AU	M2M	1	21.3	85.56	4.02	1977	1979
2	Telebus	VIC	AU	RD	1	17.8	101.38	5.72	1982	Ongoing
3	Regina	SK	Canada	M2M	4	2.3	96.86	42.26	1970	1980
4	Toronto	ON	Canada	RD	30	6.6	195.38	31.62	1973	1976
5	Abingdon		UK	RD	1	3.4	29.52	8.82	2004	2011
6	Maidstone		UK	M2F	2	4.8	42.86	8.96	2004	Ongoing
7	Eastbourne		UK	M2F	1	7.5	47.16	6.26	2004	Ongoing
8	Woughton		UK	M2F	6	9.7	97.64	10.08	1975	1975
9	Harrogate		UK	M2F	2	13.6	100.44	7.38	2004	2013
10	Carterton		UK	M2F	1	9.6	113.52	11.78	1975	1977
11	Hampstead		UK	M2F	3	9.6	123.14	12.86	1974	1975
12	Harlow		UK	RD	5	13.2	125.02	9.48	1974	1978
13	Readibus		UK	RD	12	3.4	125.40	49.72	1981	Currently paratransit
14	Sale		UK	M2M	8	12.3	129.70	10.10	1974	1976
15	Knowle & Dorridge		UK	RD	8	20.4	155.68	7.58	1975	1978
16	Greater Dayton (GDRTA)	OH	USA	M2M			0.00	18.83	2017	Ongoing
17	Utah Transit Authority (UTA)	UT	USA	RD		4.7	50.24	10.63	2008	Ongoing
18	Portland	OR	USA	RD	9	9.1	50.96	5.58	2000	Ongoing
19	Central Florida 'LYNX'	FL	USA	M2M		3.3	59.63	18.25	2008	Ongoing
20	Napa Valley (NVTA)	CA	USA	M2M		2.6	64.42	24.62	2015	Ongoing
21	Dallas (DART)	TX	USA	RD		2.5	66.63	26.65	2006	Ongoing
22	Monterey-Salinas Transit (MST)	CA	USA	M2M		4.03	78.47	19.47	2011	Ongoing
23	Salem-Keizer 'Cherriots'	OR	USA	RD		3.5	94.15	26.90	2015	2017
24	Batavia	NY	USA	M2M	5	10.1	105.10	10.34	1972	1975
25	Houston METRO	TX	USA	M2F		2.5	108.63	45.26	2015	Ongoing
26	Denver (RTD)	CO	USA	M2F		3.8	120.22	31.63	2004	Ongoing
27	North County (NCTD) - San Diego	CA	USA	M2M		2.7	140.49	52.14	2011	Ongoing
28	New York City	NY	USA	M2M	10	2.2	141.06	66.38	?	Currently paratransit
29	Kitsap Transit	WA	USA	M2M		3.66	189.33	51.68	2015	2018
30	Ann Arbor	MI	USA	M2M	3	6.1	197.10	32.12	1973	1976
31	Columbus	OH	USA	M2M	4	9.5	241.80	25.50	1971	1975
32	Alameda-Contra Costa (AC Transit)	CA	USA	M2M		3	309.96	102.84	2016	2018
33	Haddonfield	NJ	USA	M2M	12	6.5	362.30	55.66	1975	1975
34	Adelaide	SA	AU						Planned	Planned
35	Adelaide Roamzone	SA	AU						2001	Ongoing - Reboot
36	Bridj - AU		AU						2017	Ongoing
37	Canberra Flexibus	ACT	AU						2005	2011
38	Dial-a-bus, Adelaide	SA	AU						1992	1992
39	Doorstopper	TAS	AU						1997	2014
40	Kan-go	QLD	AU							Ongoing
41	Transit Taxi	SA	AU						1999	2002
42	Translink, Shellharbour	NSW	AU						1992	1993
43	Transport for NSW - 12 Regional services	NSW	AU						2017	Ongoing
44	Transport for NSW - 12 Sydney services	NSW	AU						2017	Ongoing - Scaled back
45	Belbus (dial-a-bus) Flanders		Belgium						1997	Ongoing
46	BT let's go	ON	Canada						2018	Ongoing
47	Community Shuttle	BC	Canada						2003	Ongoing
48	TAXIBUS	QC	Canada						1993	Ongoing
49	Radiobus		Czech Republic						2004	Ongoing
50	Kutsupulus		Finland						2012	2015
51	Siilinjärvi Service Line		Finland						1999	Ended
52	Allobus - Roissy/CDG Airport		France						1998	Ongoing
53	Bus du Port		France						1999	Ongoing
54	TaxiTub Douai		France						1992	Ongoing
55	Allygator shuttle		Germany						2018	2019
56	Anruf-Linien-Bus		Germany							Ongoing
57	AnrufLinienFahrt (ALF)		Germany							Ongoing
58	AnrufLinien-Taxi (ALT)		Germany							Ongoing
59	IsarTiger		Germany							Ongoing
60	RUF-BUS (Rapid Urban Flexible)		Germany						1979	Ongoing
61	TaxiBus Ludinghausen		Germany						1996	Ongoing
62	Lyft Line		Global						2014	Ongoing
63	UberPool		Global						2014	Ongoing
64	Emmen		Holland	M2F	2	7.5			1970	Ongoing
65	AllôBus and AllôNuit		Italy							Ongoing
66	Créabus		Italy							Ongoing
67	DrinBus		Italy							Ongoing
68	PersonalBus		Italy						1995	1997
69	Radiobus		Italy						2000	
70	VideoBus		Italy						2000	Ended
71	Kussbus		Luxembourg						2018	Ongoing

Why most DRT/Micro-Transits fail – What the few survivors tell us about progress

AGENCY	STATE	COUNTRY	OPERATION	FLEET SIZE	PAX PER VEH-HR	\$ PER VEH-HR	\$ PER PAX	START	END
72		Netherlands						2002	Ongoing
73		Netherlands						1990	Ongoing
74		Netherlands						1998	Ongoing
75		NZ						2018	2019
76		Poland						2007	Ongoing
77		Singapore						2019	2019
78		Sweden						1991	Ongoing
79		Switzerland						1995	Ongoing
80		UK						2002	Ongoing - nearly cut
81		UK						2002	Ongoing
82		UK						2002	2010
83		UK						2003	2015
84		UK						1974	1976
85		UK						2003	2006
86		UK						1998	2001
87		UK						2000	Ended
88		UK						1999	Ongoing
89		UK						2001	Ongoing
90		UK						2003	Ongoing
91		UK						2000	2018
92		UK							
93		UK						2002	2005
94		UK						2002	Ongoing
95		UK						1988	1989
96		UK						1991	1996
97		UK						2000	Ongoing
98		UK						2002	Ongoing - Reduced
99		UK						2001	2004
100		UK						1985	Ongoing
101		UK						2001	2010
102		UK						2000	2011
103		UK						2000	2011
104		UK						1999	Now connect2Wiltshire
105	CA	USA						1997	2011
106		USA						2014	2017
107		USA						2014	2019
108	MD	USA	M2M	2	4.4			1971	1973
109	GA	USA						Planned	Planned
110	OH	USA	RD		3.5	14.48		2016	2019
111	VA	USA						1999	Ongoing
112	KC	USA	M2M					2014	2015
113	WA	USA						2001	Ongoing
114	CA	USA						Planned	Planned
115	OH	USA	M2M	1	6.9			1971	1974
116	MD	USA						Planned	Planned
117	NV	USA						Planned	Planned
118	OR	USA						2000	Ongoing
119	TX	USA						Planned	Planned
120	WI	USA						1978	Ongoing

Why most DRT/Micro-Transits fail – what the survivors tell us about progress

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