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DEMAND RESPONSIVE TRANSIT (DRT) : JUST A RECENT NICHE OR A FUTURE REVOLUTION?

Key Words
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Public Transport (PT)
Efficiency
Passenger demand
Bus capacity
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Flexible adaptation
Intelligent Planer software

Abstract
Like many sectors the Public Transport was hit by the Covid-19 pandemic resulting in lower ridership and creating the challenge of gaining back the passenger's trust.
In the UAE, in particular, parallel to the Health and Safety measures taken by the Authorities and Operators with the traditional public bus networks, created opportunity of a new service type apparition offering shared on-demand services.
This study includes a brief description of global on-demand services, the challenges and perspectives of the model and its integration possibilities to existing Public Transport urban networks.

1. INTRODUCTION

The industrial era started from the 18th Century, pathing the way for fundamental innovations like the production mechanization. The emergence and diffusion of steam engines and later the widespread use of electric motors, permitted automation and mass production. Transportation has become one of the basic branches of industry. Overland, horse-drawn carriages stepped down in favor of steam locomotives creating the rail system. The electric rail transport in alliance with the urbanization was at the origin of a new concept: Urban Public Transport (UPT).

Public transport networks started their expansion around the world diversifying both in terms of vehicle types (metro, tram, bus, trolleybus, coaches, minibuses, vans, taxis ...) and services types (regulated, deregulated routes, fixed, on-demand ...) according to the potential and the community resources which vary with the geographical context, from very populated city centers to the suburban and rural areas and their decreasing potential.

Nowadays, UPT stands at the heart of the sustainable development by its impacts on pollution and energy efficiency. The congestion reduction targets created mass transit system to influence a significant modal shift. Internally, the industry made its homework by implementing nonpolluting transport systems based on electric vehicles and adapting the size to the passenger's needs.

Along with the technical innovations we assisted to a revolution at the political level, the recognition of the strategic nature of public transport and the creation of sustainable urban mobility plans (SUMP) approved by the decision-makers as the main orientation for future developments.

The concept of on-demand transport started to be really documented from the 1960s, especially in North America and a later in Europe. Low density areas with fewer resources have been challenged to study how to reduce costs.

The research began with a project developed at the Massachusetts Institute of Technology in 1969 using computer technology. Then the first applications of automated algorithms were created in the United States in the early 1970s. During thirty years Later the model didn't see any significant change till the internet revolution. From the 2000s, the internet break-in provided quick and varied solutions to dramatically improve the reservation system and helped reduce the time between booking and trip completion. From 2012, the smartphone boom gave the possibility to enter the market for a new kind of mobility providers.

2. THE CONCEPTION OF ON-DEMAND SERVICE

2.1. The trip planner

In the complex UPT networks, a journey planner or route planner is a specialized search engine used to find an optimal way to travel between two or more given places, using several transport modes. Searches can be optimized on different criteria, for example fastest, shortest, least modifications, cheapest.

These calculator engines were developed first in the major mass transit network but were extended later to include the schedules and possibilities of other mobility actors in the area such as taxi, carpooling, etc.

The journey planners are different from the demand responsive tools in the way that the customers are being proposed an itinerary to which they need to adapt themselves. The network is not yet moving and adapting itself to satisfy the passenger.

Looking at European countries, many have designed such platforms, just a few examples taken from the European Commission website on mobility and transport:

Table 1. Some of European Trip Planner Software (without to be considered a complete list)

Software	Country
Scotty	AT
VerkehrsPilot	AT
IDOS	CZ
9292	NL
Journey	FI
BiljRejseplanen	DK
DELFI	DE
ReiseAuskunft	DE
SITkol	PL
RESROBOT	SE
TransportDirect	UK

2.2. Hail-and-Ride

Hail-and-Ride service is also an ancestor of On-Demand service. Freed from the bus stops structure and necessity to board-in and out only at dedicated stops, the Hail-And-Ride concept is inspired from developing countries where transporters are competing on high demanding corridors, dropping and boarding at a sign from passengers.

The internet technology impacted also the traditional and classic taxi services by the introduction of booking platforms taken as new business model from new entrant in the market such as Uber or Lyft.

Merging traditional Hail and Ride and new booking possibilities enhanced by technology permitted the naturel development of a new type of service: pre-booked shared bus shuttles.

2.3. The concept of On-Demand Responsive Transport (DRT)

A DRT trip is somewhere between an individual Taxi ride and a collective public bus service. The On-Demand service can be found under different format of operation:

A. Fixed (predefined) routes, with existing fixed bus stops:
- Timetable tailoring on passengers flow (peak and of-peak hours, day/night);
- Bus capacity changing as per passenger flow evolution, flexible and quick adaptation;
- Fixed trip times but conditioned trip start.

B. Defined area (district), flexible routes, predefined stops and defined trip end stop (Bus Station):

• Predefined feeder routes, flexible stops as passenger collector role to Mass Transit Station;
• Flexible timings as per passenger request from one of the predefined pick-up location to Bus Station.

C. Just working area defined, inside district no existing routes just predefined bus stop locations:
• Communication of pick-up location (from the closer bus stop) to his asked drop-off bus stop;
• No timings (or timetable) for trips, passenger's shared journeys, just common direction defined.

D. No predefined routes, no stop locations, inside a delimited area:
• By passenger request from different pick-up locations to different drop-off locations on shared trips;
• Flexible trip times with redirection of route to pick-up a new passenger for the shared minibus.

The characteristics by location definitions are included in next table:

Table 2. DRT concepts split by type of location (area, stops)

X to N:	**N to N:**
fixed number of stops to any location in the defined area	from any location to any location in the defined area(door to door)
X to X:	**N to X**:
from fixed number of stops to fixed number of stops	from any location in the defined area to a fixed number of stops

The challenge for DRT is how to be integrated in PT systems. Many cities understood the advantage to use the DRT as a feeder service to their classic networks and a way to replace fixed routes by more efficient DRT services adapted to low ridership areas.

On the fare side, the general approach of pricing can be described as "less expensive as a taxi, more expensive than a bus". The most common payments solution is via a smartphone application on which passengers must register a profile and link a credit card. As another payment method, the public transport smart cards are increasingly imposing itself with the growing understanding of integration with the public bus network.

3. DRT SYSTEMS AROUND THE WORLD

3.1. The main DRT Software market players

Many new services have been launched over the last decade, fully implemented by private actors or through partnerships between public and private actors. The various implementations need first to be described in their similarities and differences to try to get the essence of these new developments.

Table 3. A sample of DRT Software worldwide

Region/City	Country	On-Demand Software
Helsinki	FI	VIA
Arlington (TX)	USA	VIA partner
London	UK	ViaVan
Amsterdam	NL	ViaVan
Berlin	DE	ViaVan
Liverpool	UK	VIA/ArrivaClick
Oxford	UK	VIA/PickMeUp
London	UK	VIA/Go-Ahead
Boston	USA	RideKC/Bridj
Washington DC	USA	BRideKC/ridj
Paris	FR	Flexigo
San Jose (CA)	USA	VTA Flex
Bristol	UK	Slide
Sidney	AU	Bridj/Transit
Sidney/Manly	AU	Rideplus/Transdev

3.2. Financing DRT systems

DRT services are being financed either through commercial contracts or through such subsidy schemes to possibly compensate for differences between revenues and costs for the services requested by the authorities to cover certain areas with less public transport opportunities due to the service unsustainability. Here are some contracts divided into the two main categories described above: commercial or subsidized services.

Table 4. Sample of DRT system contracts

Commercial services	Subsidized DRT systems
Bridj (Boston and Washington DC)	Kutsuplus (Helsinki)
Via (NYC, Washington DC, Chicago)	Via (Arlington, West Sacramento)
PickMeUp (Oxford Bus company)	Go Connect (Miami-Dade)
ArrivaClick (Liverpool, Sittingbourne)	RideKC: Bridj (Kansas City)
Slide (Bristol)	ViaVan (BerlKönig)
	Northern Beaches (Transport for NSW and the other Sydney trials)
	Résa'Est (Orleans Metropole)
	Flexigo (Sidney)
	VTA Flex (San Jose)
	Plustur (Northern Denmark)
	Breng flex (Arnhem, Nijmegen)

3.3. The Australian experience

The KEOLIS-Downer, in partnership with Transport for NSW, started operating KEORIDE On-Demand transport in November 2017, as part of the NSW Government On-Demand pilot program, applying subsidies for sustainability. Since the launch of this service, the community has embraced KEORIDE, praising the flexibility, reliability and high service quality delivered. KEORIDE is an app-based service, which offers a unique service design that allows customers to order a vehicle when they want to travel, to go to key hubs in the Northern beaches and/or connect to the crowded B-Line (the bus line which provide7/24 services, , big buses with more seats, more on-board comfort and additional commuters car parking facility). According to a survey conducted in June 2020, a majority of customers use KEORIDE to connect to the B-Line (78%), and 57% would have used their car if KEORIDE wasn't available.

Photo 1. Adelaide On-Demand service buses

Another example, the Transport on Demand (ToD) is provided by TRANSDEV, it is the mobility offer that is adapted to areas where the demand for shared mobility is sparse, unlike in urban areas: business parks, suburban areas, rural communities or night services. In Sidney the railway stations and the Sutherland bus stops are connected with the "on-demand" shuttle service named TRANSDEV Link project. The results have met the hopes and expectations of both: TRANSDEV and the Public Authority, the Transport for New South Wales.

As it is shown in next below statistics, in the two years of operation, as the summary of Australian DRTs, the Ridership increased to reach 80,000 Passengers/Month with potential of increase in future.

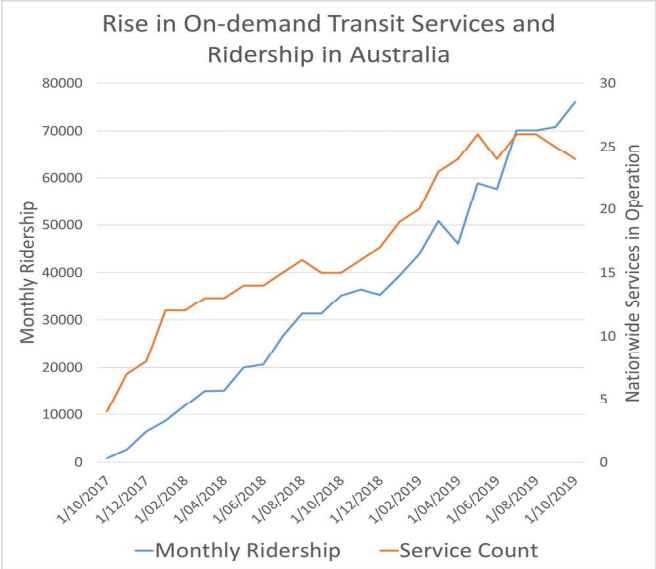

Figure 1. On-Demand Transit service ridership October 2017-2019

4. CASE STUDY: DRT EXAMPLES FROM UNITED ARAB EMIRATES

4.1. Abu Dhabi – "Links" On-Demand Service

As first the service was introduced in SHAHAMA district, a residential suburb area of Abu Dhabi with low density, with scarcity of big buildings and no real identified downtown. People who are using the public transportation are mainly commuters toward Abu Dhabi downtown, houses and farms staffing for local trips. The DRT service started on October 2020 by the collaboration between the PTA, the PT Bus Operator and VIA developer team (known worldwide for their robust software).

The user must create an account on the application and provide name, E-mail address/Mobile number. He will select the pick-up and drop-off location and make his trip order. Then the application will give a ride proposal with an estimated start time at pick-up point and the expected time of bus arrival at selected drop-off. The request can be for single passenger or a group of maximum three who should go to the same destination.

The application, using the elements of Artificial Intelligence, works automatically to identify riders request and creates routing by drawing an itinerary to link pick-up and drop-off location for all riders supported by navigation. The system will propose to the rider the closest and safest place situated in the main road for the vehicle "appointment". Payment is done through the HAFILAT smart used for PT Network.

Photo 2. Abu Dhabi On-Demand service buses

From driver side all the communications are done through an internet (GPRS) connected Tablet. He receives ride request by sequence. He has to press the Menu on Tablet (for pick-up) one a passenger is boarded. If the rider is not there, he wait select no show option after a certain time. When driver reaches to rider destination he has to press again the respective Menu on Tablet (for drop off). During trip the driver will follow the rerouting instructions received on Tablet GPS Map from Via Software.

From Operation side, the roster is established to match the service working hours as in next table:

Table 5. Driver working hours and schedules example in SHAHAMA area

Timing [h]	**0 - 6**	**6 - 7**	**7 - 13**	**13 - 21**	**21 - 22**	**22 - 23**	**23 - 24**
Bus nr. 1 - 3	0	**3** buses / **2** shifts				0	
Bus nr. 4 - 6	0		**3** buses / **2** shifts				0
Bus nr. 7	0			**1** bus / **1** shift	0		
TOTAL buses	**0**	**3**	**6**	**7**	**6**	**3**	**0**

The Drivers roster is prepared and uploaded to the application along with driver IDs, start and end duty & bus plate numbers, in total 3x2+3x2+1=13 shifts (drivers). In the Control Centre (OCC) the dispatcher will follow in Real Time the bus movement as it is shown in Fig.2, ride requests, pending requests, the operation area and position of buses. Also he will arrange Labor Law required break timing for the drivers and set the planned break in the application.

Figure 2. On-Demand Service SHAHAMA map (Real Time - September 2021)

The analysis of “classic” PT Ridership conclude a slightly decrease, less than increase in the On-Demand service, pointing the fact that the service has attracted new users.

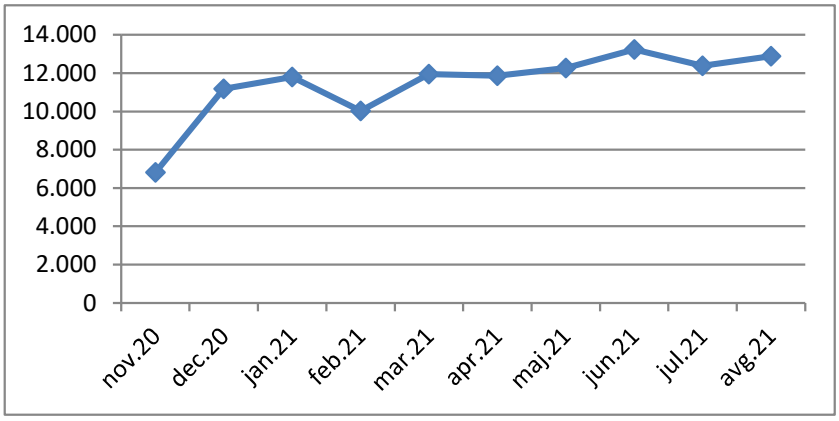

Figure 3. On-Demand Service SHAHAMA Ridership (Nov 2020 - Aug 2021)

4.2. Dubai – Bus On-Demand Service

The Roads and Transport Authority in Dubai, RTA’s service provides a fast and comfortable means of transportation for passengers who are in neighbourhoods where there are no fixed lines for mass transit routes. Passengers can download the service application to book a trip on board a "on-call bus" that goes towards their address to take them to the nearest location of public transportation from Metro stations or stations and fixed lines for public buses. The passenger can also make group reservations through the service's smart application.

Photo 3. Dubai Bus On-Demand service

The service currently is available in six regions in Dubai: Al Barsha (1, 2, 3); Dubai Internet City; International City; Dubai Silicon Oasis; The Greens and Academic City. Payment of trip it is possible via the NOL card (PT card) inside the bus, in addition to the possibility of payment via a bank credit card via the "Bus on Demand" application. RTA providing an integrated with mass transit service that encourages those in those areas to use mass transportation by reducing their waiting time, by connecting them to the nearest PT station, which ultimately serves to reduce private vehicle trips In the respective regions, and in turn contributes to reduce congestion.

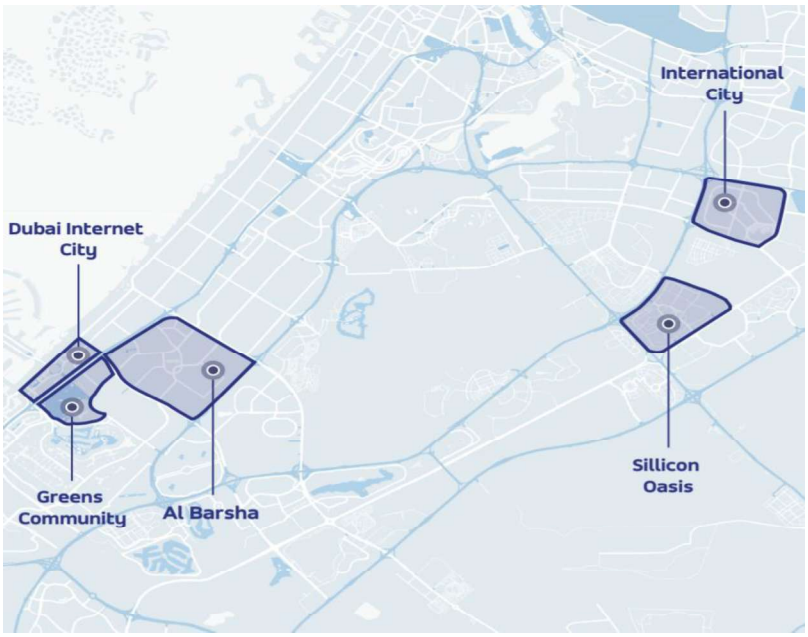

Figure 4. "Bus on Demand" Service area map in Dubai (September 2021)

The monthly average number of passengers using the service reaches 14,000 passengers, according to the statistics issued by the Authority in August 2021. The "Bus on Demand" service provides transportation within the same area, and it is not permitted to use it to travel from one region to another.

Passengers from both Emirates (Abu Dhabi and Dubai) are using with high satisfaction the newly implemented Demand Responsive Transport systems, now accepted as well-recognised and successful projects.

5. CONCLUSION

The aim of this paper is to contribute to develop knowledge about what the developments in positioning and smartphone technology bring to the table for the PT sector. Recent developments in communications and sensor technology have allowed such services to grow substantially in urban, sub-urban and rural areas. Demand responsive transport is a technology-driven shared transport service operated by a company with professional drivers with flexible schedule, and/or flexible stops and/or flexible routing. The key differentiation with traditional PT is that services are provided as a response to the demand from customers. The overarching question posed in the study was: can new technology improve DRT as sustainable service for future or is just optimization tool?

The review identified a substantial number of services that meet the criteria for what paper refers to as On-Demand PT. There are examples of both subsidized and commercial services. Typically, some services have been implemented as trials lasting for a limited period. Few of the cases have been implemented in “classic DRT territory”, in a rural, low demand context, but it appears that many of the recent or ongoing trials have been carried out in urban contexts, being implemented in major urban areas.

Four categories of routing/scheduling policies were identified in the identified cases: free floating within a continuous geographical area, fixed destination or origin, combination of free floating and fixed origin or destination, and a zone-to-zone structure. The services also utilized either physical or virtual stops.

Operating hours vary across cases with some of services in the major urban areas operating around the clock, while other services aimed at commuters operate during peak hours only.

All of overviewed cases allow bookings to be made via a smartphone application. Many of the cases also allow booking via other means, e.g. online or by phone. The study identified different approaches to handling real-time requests and pre-bookings.

There are some cases in the study where payment is integrated with the general PT system, as it’s happen in United Arab Emirates examples of Abu Dhabi or Dubai, enabling payment using PT smart cards. Additionally, there are also few examples of systems that are integrated with general PT systems, searchable in the local PT planner. Thus, it can be argued that most cases in this study operate as standalone systems, in which links to, and integration with, other forms of PT are limited.

Another issue concerns the effect on accessibility. DRT services could significantly affect accessibility for certain groups of people who live in low density areas that are genuinely hard to service using fixed route PT. In this type of context, it could be politically justified to accept a costly DRT system if it provides clear improvements in accessibility for those people in the population who have limited access to transport compared to the present situation.

On-demand ridesharing offers the opportunity to enrich the traditional PT offer and diversify the service portfolio, hence helping to attract new user groups who may currently be dependent on private vehicles. They are particularly useful where the cost of fixed route, fixed schedule services may be unusually high in proportion to the demand such as in sparsely populated areas or during random times of the day. It can also be useful in first/last mile connectivity. For PTOs, it could therefore be a good opportunity to adopt new tools and new ways of working. Coordinating on-demand ridesharing with scheduled PT, for example through the pricing system or operational time, can result in a win-win proposition. This coordination is also a key to keeping the sector relevant in the context of the autonomous vehicle revolution. Furthermore, efficiently integrating on-demand ride-sharing options by building integrated mobility platforms such as MaaS will pave the way towards more sustainable urban mobility systems.

As a main conclusion, there are no indications that technology is a game changer for improving DRT to any significant extent. A benevolent interpretation of the comparison of productivity (expressed as passengers per revenue hour) between the reviewed cases and traditional DRT indicates that, in some cases, there may be some incremental gains. However, there are also examples of cases in which productivity was lower than traditional DRT. This suggests that new technology is no panacea for fixing the problems of DRT.

DRT became undoubtedly a potential partner for the future PT Networks if it is considered as a complement to the Mass Transit systems, for dedicated areas or day types or time bands but it will never replace the Mass Transit Networks inside the dense areas.

The debate about whether is better “to spend tax payer’s money” for subsidized contracts or “investors’ funds” for commercial services: on DRT solution rather than improving the fixed routes will undoubtedly continue, arguments pros and cons are many, positions could be different, but PTA (and PTO) main target is to reach PT operational and financial parameters to the maximum efficiency.

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