Demand Responsive Transport Systems

An Alternative to the Private Car?

Prof. Ing. Adrian Muscat, University of Malta

Sustainable Mobility in Malta, Smart City, 30th November 2012

Aims for this contribution

- Raise LOCAL awareness on "Demand Responsive Transport Systems"

- Report on a first order "Dial-a-Ride System" feasibility study

- Background and Motivation

- The Dial-a-Ride System

- Define Service Area and System Model

- Cost of Private Car and Taxi systems

- Cost for Dial-a-ride

- Conclusions

Background and Motivation

- We have an over engineered, inefficient and expensive private mobility system.

- More cars…more roads…more parking…less open spaces

- Or more cars… longer trip times

- We are at a stalemate…we need a paradigm change… new policies… etc

If, as from tomorrow,
our society starts charging for parking,
the mobility system will collapse.

Bicycles at the back of our shed may save us!

A decrease in car ownership can help in solving many other problems.

Can we decrease car ownership whilst maintaining current mobility levels and quality?

Why do many SINGLE persons commute a few kilometres, to and from work in their own private car?

Flexibility (maybe) ...or freedom

...if a parking is available

... or, is it because there is NO ALTERNATIVE?

What is the cost of a private car?

Assuming 10,000km/year

TYPE	Small	Medium	Large
Euros/km	0.30	0.40	0.50

And less km?

km	3000	6000	10000
Cost/km	0.80	0.45	0.30

For a small car!

Add time incurred looking for a parking slot.

current Alternatives?

- Public Mass Transport Systems. User fits his/her life around the timetable. Daily trip duration can be significant and tiring. Works best in high density areas

- Static private mass transport systems (not for individuals but for organized groups)

- Private Taxis (expensive)

Can we get more from the PTS?

- Probably not.

- A higher capacity public transport? Cost per commuter may increase.

- Lowering costs implies longer walking distances... marginalizes the less physically able. (unless we provide an alternative)

- Lacks personalization

What's 'ON' in other societies

- Walk more

- Cycle more

- Make greater use of public transport….
  because they either walk more…or because
  some areas are denser…parking costs money.

- Some car share systems.

The above systems do not work on our infrastructure

Consider a system that is attractive to those who demand

- Reasonable trip times

- Personal service and flexibility

- Service at a reasonable cost

- Can be implemented over the current infrastructure

- Consider demand responsive systems to reduce network congestion, pollution and pave the way for green initiatives.

- Evaluate whether such systems can compete with the private car and therefore help in reducing congestion, car ownership and social cost.

So what are Demand Responsive Transport Systems?

- In the absence of a private car the fastest way of travelling from A to B is to flag a taxi at the curb...hop in and travel directly to B.

- A better alternative is to dial a taxi.... you may have to incur a waiting period, but the journey time is the minimum achievable. If you pre-book, the waiting time is usually zero.

- But this is a very expensive service....for the daily commute.

- What if a taxi is shareable. i.e we have to physically share the taxi with other passengers

- Then the cost is a fraction of the whole.

- And the system is called Dial-a-Ride instead of dial a taxi!

- Alternatively it is similar to PTS, but with a schedule that changes in real-time.

- But....the journey time increases....is 30-50% tolerable?

History for the dial-a-ride

- Informal flagging at the curb…common in less developed countries. No central control. So gain is minimal and service is available at points of high concentration. e.g taxi driver picks up four independent travellers whose drop-off points are along a common route.

- Specialized community services….usually a static system. i.e booking occurs at least a day before.

- Trial in Genoa. Dial-a-ride. Call at least 30min before. The financial cost is high and is subsidized by the council. Services sub-urban areas...mostly at off-peak hrs. Dispatch is human controlled.

- We are interested in a dynamic dial-a-ride. Mostly for door-to-door rather than last mile connection.

A good system should provide a personalized service.

(1) pick-up and drop-off data transferred should be accurate and fast,

(2) customer should receive timely personalized updates, such as estimated time of pick-up and taxi presence, and

(3) dispatch is fully machine automated. Human interventions are costly and disruptive in this case.

Leverage infrastructural components

- Smart Mobile Phone

- Cellular Mobile Network (ABC)

- Routing and scheduling algorithms at central office

- In-vehicle navigation and communication systems.

- Electronic Micro-payment systems

The engineering of such a system requires an understanding of the relationship between journey time, cost and quality of service.

Probably new legislation is required for (1) micro payments, and (2) taxi sharing.

Modelling the System

- In this study we make use of advanced 1st order models.

- Private car costs are quite straightforward.

- Dial-a-Taxi costs are not. So we use a model to calibrate the system model prices to those in real-life.

- Cost of cars ranges from Euro 10k to 30k.

- For the private car we assume a 10 year lifespan and for taxis we assume 2 years - 40% of cost per annum. Drivers cost Euro 6 / hour of service. Other costs include maintenance services, fuel, insurance and central office costs.

First Order Model

- Next Event Computational Model
- Homogeneous service area: $400 km^2$
- QoS Parameters are: Waiting Time, Trip Time, Tardiness
- System Utilisation Parameters: Distance to PickUp and Dead Time
- Time window of 12 hours
- Mean Speed Model: Gaussian (u=30, s=5)

- What is the cost of an independent taxi?

- The problem is to find the average trips daily over 12 hours as a function of QoS, mainly tardiness.

- Discrete Event model over a 400km^2 area to determine # Trips vs QoS.

# Trips	6	9	13
Cost/trip	19	13	9.5
Mean Tardiness/trip	2.1	9.5	21.2
Dead Time/trip	57	30.6	10.0
Mean Duty Cycle	46%	60%	82%

- What is the cost when we Dial a Taxi?

- Discrete Event model over a 400km^2 area and car fleet of 20 taxis.

- Includes central office costs.

# Trips/vehicle	7	11	13
Cost/trip	17	12	10
Mean Wait Time	1.4	2.1	10.8
Dead Time	30	14.5	5.1
Mean Duty Cycle	61%	77%	90%

- And the dial –a-ride system ?

- Customers are calling and demanding service instantaneously. The system responds with a service contract ("Will pick-you up in circa 12min and drop you off at 18.30pm"). The customer accepts or rejects.

- Taxi schedule updates and changes occur in real-time.

- The efficiency and cost of the system depend largely on the scheduling and optimization algorithm and on service area characteristics.

- In academia this problem is called the Dynamic Dial-a-Ride Problem and has received a lot of attention by researchers lately.

- The most promising results in the open literature indicate a 30% increase trip time over a direct source to sink trip.

- Our first order model indicates that increase in trip time is dependent mainly on traffic characteristics offered to the system, size of vehicle and number of vehicles in operation.

- For 6-8 passenger vehicles, system operating at 70% of full-capacity and covering a service area of 90km^2 with a total of 18 vehicles increase in trip time is 50%. Better algorithms and non-homogeneous service areas can lead to a 30% increase in trip time.

- For 6-8 passenger vehicles, 400km^2 with a total of 28 vehicles increase in trip time is 75%. Still less than PTS and service is door-door.
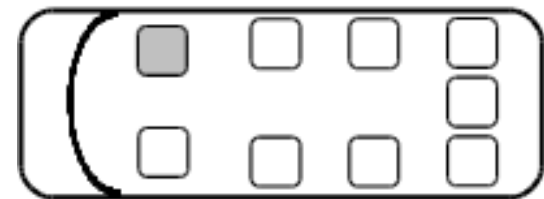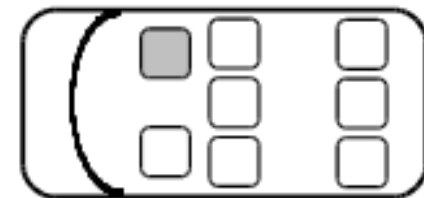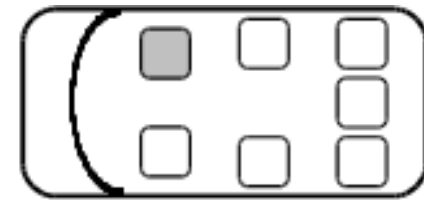
Mean cost per passenger is 1.45/1.90 Euro. (8/6 seat)

Trip Length	2km	4km	6km	8km
Private car Fuel only	0.25	0.50	0.75	1.00
Private car	0.60	1.20	1.80	2.40
+ parking	2.00 - 9.00	2.00 - 9.00	2.00 - 9.00	2.00 - 9.00
DaRS 8 seat car	0.80	1.20	1.40	1.80

Conclusions

- This study demonstrates that DaRS can possibly operate locally as a door-door mid-market alternative system to the private car.

- Vehicles are comfortable, seat 6 to 8 passengers, ideally EURO 5 engines.

- Customers need a smart phone, data plan and NFC.

- Door to Door service, close-to-Door or pre-determined stops in some cases, price differential can be applied.

Thank you!