PERSONAL RAPID TRANSIT FOR CANBERRA

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We consider personal rapid transit (PRT) as a sustainable transit system for Canberra. We discuss the advantages of PRT and show that is has all of the advantages and features of both car ownership and public transport, with added attractions of its own. The most appealing feature of PRT is its cost. Previous studies have shown PRT to be cheaper than most other public transport systems. We show that PRT would be remarkably cost effective for a city planned like Canberra, particularly if there were sufficient incentives to significantly cut car ownership, including enhancement of the current excellent bicycle network.

INTRODUCTION

The idea of personal rapid transit (PRT) systems has been around since at least 1953. We explain the basis of such a system here, expanding on the detail at appropriate points later in the paper. The basis of PRT is that there are a number of "pods'', which travel on a system of tracks. The pods can be of varying sizes from single commuter to any number – say, as many as a bus or even a standard commuter train, though such large sizes would significantly change the personal nature of the system. Commuters can either request a pod by phone, SMS, Internet or at the nearest *pod-stop* (similar to a bus stop). A pod will either be already waiting or will arrive, most often, in less than a minute. The commuter (or party of commuters) enters the pod, which takes them to their desired location.

At present, there are a number of systems in either the planning or building stages. A simple one-track system is being built at the new Terminal 5 at London's Heathrow airport (British Airport Authority 2007). This system will initially transport passengers from the car park to the terminal, with plans for expansion later. The system is costing £25 million for 3.8km of track and 18 vehicles, each of which can seat four passengers and their luggage. The manufacturer is Advanced Transport Systems Ltd, and the system boasts 70% lower carbon emissions than cars and 50% lower than buses and trains. The main drawback with this particular system is that the maximum pod speed is only 40km/h (Advanced Transport Systems Ltd 2007). This would probably not be acceptable in Canberra.

The UK town of Daventry commissioned a comprehensive study into alternative public transport solutions, for which PRT was declared to be the front-runner (Sinclair Knight Merz 2008). The town wishes to increase its population from 23,000 to 40,000 and believes that a more effective public transport system will facilitate this expansion (Sinclair Knight Merz 2008). Procurement for a pilot system is underway. It is expected to consist of a 5km track with five stations and a depot, with a fleet of on-demand pods. A supplier is expected to be appointed by mid-2009 (Daventry District Council 2008).

Other planned implementations include a PRT system in the Abu Dhabi sustainable city of Masdar. Masdar City is 6.5 square km in size and aims to be the first zero-carbon-emission city in the world. It is expected to be completed by 2015, and to have a residential population of 40,000 people with 50,000 additional workers. Only companies dedicated to sustainable and alternative energy sources will be allowed in the city (ANZSES 2008).

This paper explores the viability of implementing a PRT system in Canberra, Australia's compact, well-planned capital city. We take into consideration the current state of public transport in Canberra; the city's layout; population demography; and the sustainable transport plans of the Australian Capital Territory (ACT) government. PRT has all of the advantages of cars over public transport and all of the advantages of public transport over cars, and then more advantages of its own. We come to the conclusion that Canberra is eminently suitable for implementation of a PRT system and vice versa.

WHY CANBERRA?

Why is Canberra a perfect candidate for being a showcase sustainable city, including an all-pervasive PRT system? Canberra has a manageable population of around 340,000 people and it is the capital of Australia. Canberra is widely acknowledged as being well-planned and easy to get around. This is true – as long as you have access to a car. Like most modern cities for the better part of the last century, Canberra has been designed for commuting by car. While it is rarely cheaper to own a vehicle than to catch public transport when all on-road costs are taken into account, the convenience of owning and using a car outweighs the added cost. A further issue for Canberra is that, while rising petrol costs are adding to the cost issue, parking in Canberra is more readily available and cheap when compared with other capital cities in Australia. The incentive to use public transport, particularly in its current multiple user form, is low.

ACT GOVERNMENT PLANS

The ACT government is keen to improve the sustainability of transport within the ACT. The following quote is from (Department of Territory and Municipal Services 2004):

> "With this plan, Canberra will achieve a transport system that has lower overall costs, particularly lower greenhouse gas emissions, lower air pollution, reduced accidents and lower health costs, and provides more transport options for the community. The transport system will also support the achievement of the economic and social goals for Canberra as outlined in The Canberra Plan."

We show that all of these planned achievements are obtainable via PRT.

As part of the sustainable transport plan, the ACT government has undertaken studies into the implementation of a bus transitway between the Belconnen town centre and the City (Department of Territory and Municipal Services 2005). It was found that this system was not feasible at this time, due to the small number of commuters that it could attract compared with the costs involved. This strengthens the argument for a more (or all) pervasive PRT system being an excellent candidate for sustainable transport in Canberra.

PUBLIC TRANSPORT IN CANBERRA

CANBERRA'S LAYOUT

Canberra consists of five town centres: Gunghalin, Belconnen, Civic, Woden and Tuggeranong. To catch a bus from a suburb of one town centre to a suburb of another generally means catching a bus that stops in at least one town centre on the way, and possibly two or even three, depending

on the particular suburbs. It most often also means changing buses, with no guarantee of aligned timetables. So, a trip that takes 10 minutes by car can take over an hour by bus, depending on the time of day or day of the week. For example, a check of bus trips between Turner and Kingston shows that, including walking times between dwellings and bus stops, during the week a trip cannot be found which takes less than 40 minutes. All three trips, in this instance, required only one bus. Further, peak services were only every half an hour and daytime services dropped back to once per hour. This is clearly not very convenient, and weekend trips were even worse. By car this same trip takes around 10 minutes. One of the potential routes included a 15 minute walk which is not appealing late at night. Why would you choose a 40 minute option when you have a more comfortable 10 minute option sitting in your garage? You wouldn't. Canberra's layout, with its many town centres with allied suburbs, given its population density, does not allow for an efficient public transport network.

BUSES IN CANBERRA

Currently, public transport in Canberra consists of the public bus system, operated by ACTION buses (Action Buses Website 2008). This system boasts that 95% of people in most Canberra suburbs are within 500m of a bus stop with a route to their local town centre (Action Buses History 2008).

In the financial year 2006/07, Canberra's bus authority, ACTION, had a fleet of 379 buses, running around 80 weekday bus routes, with 17.1 million passenger trips (Department of Territory and Municipal Services 2007). With a population of 340,000, this equates to around 50 trips per person per year. This is equivalent to every person in Canberra taking one bus trip every week, but only one way. Canberra has only one major mode of public transport, making it difficult to make meaningful comparisons with other capital cities. Similar figures for Sydney indicate around 45 trips per person (State Transit Authority of NSW 2007). However, Sydney has an extensive train network, which would bring the patronage level up significantly. Further, Canberra has the lowest unemployment rate of all capital cities in the country (Australian Bureau of Statistics 2008), being 1.4% below the national average in 2006–07. Canberra should have greater demand for public transport, based on the percentage of regular trips made by those commuting to work, which make up a large percentage of commuter trips.

If we look at the numbers of passengers per bus in the fleet, we find that the number of passenger trips per bus in the fleet is 45,100 for Canberra and 104,000 for Sydney, highlighting the relative inefficiency of Canberra's bus service. Further, a report on an integrated transport framework, by the ACT Government, shows that Canberra is lagging behind other capital cities in Australia when it comes to catching public transport to work (Department of Territory and Municipal Services 2008)

So, in comparison with other Australian cities, Canberra is slightly below par. But, if it were at or even slightly above par, would this be good enough? If we are going to improve our greenhouse gas emissions (GHG) through transport we either need to change cars or change our transport. Transport in Australia contributes 14% of GHG emissions (Australian Transport Council, Environment Protection and Heritage Council, Vehicle Fuel Efficiency Working Group 2008). PRT has the potential to bring it down to zero by avoiding fossil fuels altogether.

PRT SYSTEM FEATURES

THE ATTRACTION OF PRT

There are a number of attractions of cars for individual commuters over current public transport options. There are also a few advantages that public transport has over cars. PRT has all of the attractions and advantages of both, plus some added advantages both for the individual commuter and for society as a whole. We now consider these attractions, grouped into categories.

CONVENIENCE

One of the strongest attractions of having one's own vehicle at one's beck and call is convenience: it is ready when you are, it provides door-to-door service, you can take the most direct route to your destination and you aren't slowed down by other commuters entering and leaving your vehicle at different stops.

PRT offers all of the above, plus has the following advantages over cars. In a PRT system, there is no stopping at all. There is no congestion, no traffic jams and no traffic lights. All PRT pods are connected to a high-speed broadband network that logs all pod positions and destinations, allowing planning of all pod routes based on the current state of the pod network. Pod stations are placed on separate lengths of track, long enough to allow for acceleration and deceleration, so that pods on the same route, but passing that station, are not affected.

Similarly to public transport, with PRT the individual commuter is not responsible for maintenance. No more visits to the carwash or trying to find a petrol station when you're running late or it's late at night, or any other time.

PRT is also accessible to everyone, young or old. Apart from added safety, discussed below, PRT improves overall public mobility. One has to be at least 17, with good eyesight, hearing and working limbs to be able to drive a car. PRT is readily accessible to people in wheelchairs or with prams or lots of shopping to carry. Anyone can use PRT.

Cycle racks can easily be attached to all PRT pods. At present in Canberra only certain routes guarantee bike racks, although even that is not 100%, and there are only ever two racks on any bus.

PERSONAL SPACE AND COMFORT

Cars allow us our personal space. When we want to share our journey with other people, we get to choose who they are. We don't have to share untold germs with other commuters sneezing or coughing around us. We can choose what music is playing and we don't have to use annoying earplugs to avoid annoying other passengers.

Again PRT gets all ticks for these advantages of cars over public transport. Taking public transport, on the other hand, allows us extra time to do things like catch up on reading, homework, putting on make-up, or just allowing us chill-out time between home and work or school. PRT also gives us these advantages, only better. You don't always get a seat on public transport, particularly in peak time, which automatically takes away most of the aforementioned advantages. Seats on PRT are guaranteed. The ride is much smoother than public transport, making these activities easier and more comfortable to carry out. There are no more worries about making mobile phone calls while you're driving, no concerns about privacy or annoying other passengers. Further, all pods would have wireless Internet access, as a consequence of the wireless network

required for pod control and communications. Other possibilities include entertainment amenities such as DVD and CD players.

SAFETY AND SECURITY

In cars we don't have control over what other drivers are doing. In PRT all pods are controlled according to the positions and movements of all other currently mobile pods. Accident rates would be practically nil. All pods and pod stations would be fitted with closed circuit television, as well as emergency buttons, similar to those in lifts.

PAYMENT OPTIONS

To allow for as many types of commuters as possible, a number of flexible payment options would be required, similar to current options for public transport. However, with PRT as the sole mode of transport in a city, even more convenient options would be required. Further, payment options would need to be simple to use and easy to understand. A possible set of options would be:

- membership card with an annual fee
- weekly/monthly pass
- X-trip ticket, where X = 10, 20 etc
- single- or return-trip ticket

Each of these payment options would also be available at different levels, such as concession rates. Annual membership cards and weekly/monthly passes would be similar to credit cards. The user would keep the same card until it became lost or unusable through damage or wear. The card would have a magnetic strip with identifying information such as a user number and dates of validity. The user would book a pod online or via phone or SMS for one or many trips. The booking would include the pick-up pod stop (possibly at their door for an all-pervasive system) and the destination pod stop. The user is given an identifier for their pod for each trip. When the user arrives at the pick-up pod stop they identify their pod, which will only open for their card, which is swiped across a reader on the pod door. The process would be similar for X-trip tickets, except that these tickets would be disposable (or, preferably, recyclable). Commuters requiring just a single or return trip would book them in the same way as the longer-term commuters, however they would simply be given a codeword to be spoken into a microphone sensor in the pod door, to allow them access.

The system could also allow for entering number of passengers and pieces and sizes of luggage, with the default being one passenger and no luggage. Pods could be fitted with weight sensors, which could set off an alarm and disable the pod if significantly more weight was detected than expected. This gives an added safety feature if someone enters your pod uninvited.

There is scope for access options to be more like those of airlines than regular public transport systems. For example, there could be different classes of pods equivalent to "first", "business" and "economy", each with different internal features. The differences could be in seating comfort, flooring/décor/fittings and included amenities, though there must be a minimum level of service, regardless of the class of travel. It would seriously undermine the integrity of the system if travel

times or waiting periods were different for the different classes as this would tend to further disadvantage the already relatively disadvantaged.

OTHER CONSIDERATIONS

EMERGENCY SERVICES VEHICLES

The effect on emergency services would be to improve the time between making an emergency call and the arrival of the service. Emergency service vehicles would not get caught in traffic and could be given automatic right of way. Nor would they get lost. If the caller was calling from a fixed phone, the address would be automatically "read'' from the header of the transmitted digital packets comprising the call. If the caller were calling from a cellular phone, the address stated by the caller would be automatically corroborated using automatic positioning from base-station signal strength measurements.

Specially equipped emergency service pods would run on the same track network as commuter pods. Because of the automated nature of the system, all in-transit pods that would impede the progress of an emergency service pod would be pulled into a pod-stop in time to avoid impedance, with as little delay to the incumbent commuters as possible.

Such pods would also be able to move "off-track'' depending upon the level of penetration of the track system. For a door-to-door system, off-track ability would be unnecessary. For a system which only guarantees, say, 100-200 m for any commuter to a pod-stop, "off-track'' ability would be necessary, particularly for fire engines and ambulances.

IMMUNITY TO SABOTAGE OR TERRORISM

A strategic attack to the PRT system could cripple the city for a number of weeks if several arterial tracks were targeted at once. Attacks could either be made to pods or to the track.

Pod attacks would be very difficult to undertake due to a number of possible electronic surveillance methods. Each pod would be fitted with CCTV which would allow for the monitoring of suspicious behaviour. Further, each pod could also be fitted with sensors to monitor changes in weight or balance if a bomb was attached to the vehicle at some point. It may even be possible to have sensors on-board which detect explosive chemicals, similarly to the scanning devices used on random individuals at airports. If the cost were prohibitive for a comprehensive layout, these could be placed on random pods.

Attacks to the track would be more difficult to detect, depending upon the nature of the attack. An attack with an explosive device attached to the track could be picked up in a number of ways. Firstly, movement sensors could detect the presence of anyone too close to the track. Again, sensors like accelerometers could also pick up vibrations in the track associated with someone touching the track or attaching something to it. In the case of an attack to either a pod or the track, the nature of the pod-track system would determine the most appropriate monitoring.

However, the serious effects of a crippling attack strongly suggest that the nature of the pod-track system must be as modular and robust as possible. For example, apart from some bridges and the elaborate overpass/underpass systems in some cities, most motor vehicle road systems are relatively immune to such attacks. The average car requires only relatively smooth ground upon which to travel. As long as there are no big rocks or large deep holes, and the road is not more than an inch or so deep in water, a car can get through. Further, there is generally a large

amount of redundancy built-in to road systems, either from planning or from the way the road system simply developed from early horse tracks. It is a robust system. A similar approach is required for a PRT system.

PEDESTRIANS AND CYCLISTS

Canberra has an extensive network of bicycle paths. This network would be maintained and expanded with the introduction of PRT. Without cars, commuters may also feel inclined to ride more often, particularly during the warmer months. An enhanced cycle-path network would encourage increased take-up of cycling. This will also bring health benefits for the city as a whole.

One issue with there being no traffic lights and the stipulation of non-stop travel for PRT pods is how pedestrians and cyclists get past the pods. If the PRT system is all on raised tracks, there is no issue. Pedestrian and cycle paths would simply run beneath. For systems with ground-level tracks, careful planning needs to be undertaken. There would need to be underpasses and overpasses, as appropriate for the location. As there would need to be a large number of these, they would need to be cheap to construct and low-maintenance.

Another possibility would be to have the PRT system run in a series of trenches so that pedestrian/bicycle paths would be simple bridges over the top. To make the view more interesting to pod commuters, windows could turn into screens for which they could choose the view or else they could simply watch a movie. Views could be, for example, a city, either the one they're in, or Paris or New York, say, or a forest, ocean or relaxing rolling green hills view. Commuters would effectively be entering a 3D theatre with their chosen view moving along as they do.

OTHER SPECIAL PURPOSE VEHICLES

Of course, commuters and emergency services are not the only ones who need to get around a city. Many people work from their vehicles, such as those who work in a trade or in the delivery services. Purpose-built pods would be built for trades-people; they could be rented on a long-term basis so that a plumber, for example, would not need to load and remove all of their tools and equipment every time they went to a new job.

Larger loads, such as for builders or stock deliveries to stores, could also be accommodated with appropriate scheduling. Stock or supplies coming from out of the city would be delivered to large depots on the outskirts of the city. (If the whole country were PRT-implemented, large inter-city deliveries would be by rail. If only Canberra were PRT, interstate deliveries could still arrive and be despatched by truck.) The PRT system would have large trailers for transporting larger amounts of goods around the city. These trailers would run more slowly than the commuter pods and so would only run in the late evening/early morning when commuter demand was very low. This is very similar to the way deliveries are made now with an all-pervasive road system.

Further, there would be scope, if demand called for it, to allow commuters to buy their own vehicles. This would satisfy those who like to distinguish themselves by their vehicle. A certain number of privately owned pods would also help to offset the cost of the system. Such vehicles would have to meet strict design specifications so as to be able to be accommodated in the pod route scheduling.

IMPLEMENTATION

Ideally, we would like to see a fully-penetrative PRT system with zero car ownership. This would have a number of benefits, in addition to those mentioned earlier, to Canberra society as a whole: lower traffic noise levels, as PRT is electric, and almost 100% uptake of the PRT system and greater uptake of cycling, leading to a healthier society.

One issue with PRT running off the electricity mains, as they stand, means zero GHG emissions in the area of use of the PRT system, but emissions would still be produced elsewhere. To be really sustainable and climate-change friendly, PRT pods would need to be solar powered. Further, it is well-known that one of the energy issues with current vehicles is that most of the effort goes into moving the vehicle. By having the propulsion system within the track rather than on the vehicle and with solar technology efficiencies and new light-weight, strong composite material technologies improving rapidly every year, a zero-emission PRT system is not out of the question.

Recent studies have shown that PRT systems outperform most other forms of public transport in terms of cost per passenger journey (Buchanan et al. 2005) as well as implementation costs (Tegnér et al. 2007). While different systems cost slightly different amounts, averaging over different sources indicates that the cost would be around $10.6 million per km of track, but could be as low as $6 million. The length of road lanes in Canberra is 5900 km, or 20 million square metres in area (Department of Territory and Municipal Services II 2008) with an annual maintenance cost of $6530 per lane km (Department of Territory and Municipal Services III 2008), resulting in $38.5 million per year in road maintenance alone. If a PRT system were only implemented on main roads, roads between suburbs and arterial roads within suburbs, this is of the order of 500km in length, translating to 1000km in tracks for a two-way system. The cost of this level of penetration, which is comparable to the current bus route network, at $10.6 million per km of track is $10.6 billion and, at $6 million per track km is $6 billion. A staggered introduction combined with greater incentives for reducing reliance on cars, as well as taking into account the value of the environmental, health and other savings, would make PRT a worthwhile long-tem investment.

There would be further savings and benefits from the reduction in traffic work for the police force. There would be no more need for random breath testing (pods are simple enough to use when inebriated), speed cameras, random vehicle inspections, chasing up stolen vehicles, high-speed car chases, not to mention accident attendance and administration.

THE ROLE OF BROADBAND

Broadband technology is essential to the successful and effective running of a PRT system. It is required at the very least for coordination of the pods, involving frequent position and status updates. Safety and security measures will require sensors for purposes ranging from detection of fire, unexpected pod loads, overloaded pods, emergency service vehicles and track hazards. And, finally, broadband is required for conveniences for commuters such as Internet access. A PRT system would not be feasible without broadband technology.

CONCLUSIONS

Awareness of the human contribution to climate change has intensified over the past two years. Governments are finally taking climate change and sustainability seriously and beginning to search for ways of addressing them. One of the areas being targeted is transport. In this paper, we have considered the implementation of a PRT system for Canberra, Australia's capital city. While Canberra has a compact size, its layout does not allow for an efficient public transport system. However, the very reasons it is not suitable for a public transport system make it suitable for a PRT system. We have shown that implementation of a PRT system in Canberra, even to a greater level of penetration than the current bus system, would be cost effective, particularly with increased incentives for reducing car use. Implementation of PRT in Canberra would be a great step towards making our capital city a showcase Sustainable City, making Australia a world leader in this area.

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