SOME 21ST CENTURY TRANSPORTATION SOLUTIONS

A COMPARATIVE ANALYSIS

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ABSTRACT

This paper compares urban transportation solutions that are currently in use or under consideration including personal rapid transit (PRT), bus rapid transit (BRT), light rail transit (LRT), electric bicycle rapid transit (BikeRT), transportation network companies (TNC) like Uber & Lyft and small driverless shuttles (A-shuttles). Since these solutions are often presented without an evaluation of which problems they address and which they ignore, or even exacerbate, the paper develops a methodology to evaluate and compare them. A simplified systems-engineering analysis is undertaken whereby the fundamental requirements for an effective 21st Century transportation system are derived from the results of a series of public workshops. These requirements include: safe and secure; reliable; cost-effective; reduces VMT and congestion; sustainable; ADA compliant; widespread service area. Goals are developed for each requirement. The ability of each of the solutions to meet the goal for each requirement is then considered and rated. The results are summarized and ways of combining solutions considered. It is suggested that those questioning the presented results use the same process to develop their own list of requirements and score their preferred solutions against those requirements.

THE PROBLEM

Congestion is getting worse, accident rates are terrible and are not improving, transit is ineffective and underutilized, many have difficulty getting to work, school, medical care and entertainment. Governments do little that is innovative while the private sector keeps promising solutions that struggle to emerge or do not help much. Solutions to urban transportation issues that are currently in use or under consideration include personal rapid transit (PRT), bus rapid transit (BRT), light rail transit (LRT), electric bicycle rapid transit (BikeRT), transportation network companies (TNC) like Uber & Lyft and small driverless shuttles (A-shuttles). The problem with many of these solutions is that they are presented without an evaluation of which problems they address and which they ignore, or even exacerbate. They sound good at first but can divert us from implementing solutions that really do work.

Figure 1. Ultra PRT

Figure 2. BRT

Figure 3. LRT

A simplified systems-engineering approach follows whereby the fundamental requirements and goals for an effective 21st Century transportation system are developed. The ability of each of the above solutions to meet each requirement is then considered and rated (1, low to 5, high).

Workshops have been held in Colorado Springs, Greenville, Mauldin and Clemson where members of the public as well as transportation professionals developed and ranked their requirements for a transportation solution. The following section is based on the workshop results and presents the requirements in approximate descending order of importance.

An additional requirement has been added that did not result directly from these workshops but incorporates requirements that did (such as convenient; high frequency; short travel time with no transfers; and comfortable). This is the ability of a solution to reduce vehicle (car and light truck) miles travelled (VMT) and thus congestion. All the solutions have been considered in the context of their being retrofitted to the existing urban

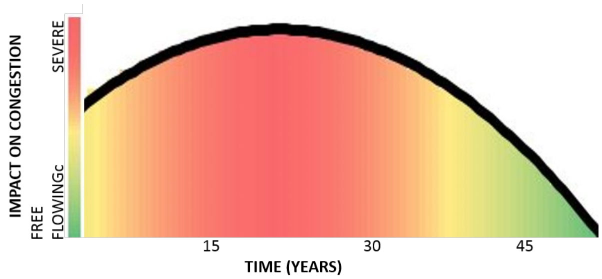

Figure 4. Impact of Driverless Cars on Congestion Data source: ITS International

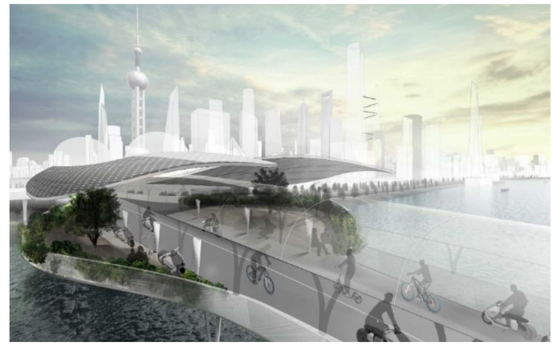

Figure 5. BMW BikeRT

fabric in the next five to ten years when driverless cars are anticipated to be adding to VMT and congestion and long before it is possible for them to start reducing one or both. If an alternative works well for its riders but does little or nothing to alleviate VMT and road congestion, it will not be a great solution.

It is important to note that, for these purposes, each mode is considered to have capabilities they already have or are on the point of achieving. All, except for bicycles, are assumed to be driverless with no need for an on-board attendant.

THE REQUIREMENTS

Safe and Secure

Landing and taking off in all kinds of weather at high speeds is inherently dangerous, yet the airlines have achieved safety records far exceeding those of surface modes. New modes must match these records or be doomed to being killed by bad publicity (the press already focuses disproportionately on driverless car accidents).

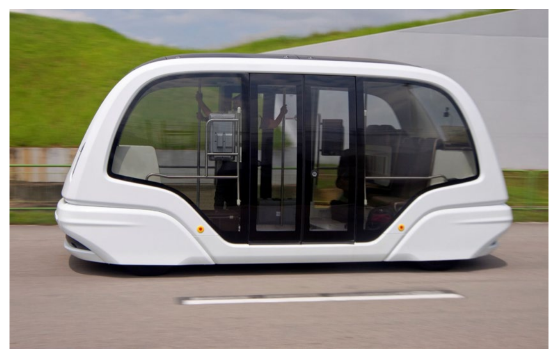

Figure 6. 2getthere A-shuttle

<u>Goal</u>

Meet American Society of Civil Engineers Automated People Mover Standards (ASCE APM Standards) requirements for safety and/or match US airline safety and security records.

<u>Meeting the Goal</u>

PRT: PRT has achieved over 200 million injury-free passenger miles. It achieves this exceptional safety by having exclusive guideways separated from all other traffic and pedestrians. There are no crossings, only merges and diverges. PRT systems are designed to meet the ASCE APM Standards. Stations and vehicle interiors are monitored by internal CCTV.

BRT: BRT has exclusive lanes but these cross other traffic. Vehicles can be crammed with passengers with little or no monitoring of personal security.

LRT: Portions of LRT routes often travel along city streets exposing the vehicles to crossing traffic and pedestrians. Vehicles can be crammed with passengers with little or no monitoring of personal security.

BikeRT: Slower speeds and separation from other traffic enhance safety. Merges and intersections can be slightly problematic.

TNC: Even when driverless, these vehicles only seem to promise to reduce the horrendous automobile accident rate by a little more than half.

A-shuttles: These vehicles will probably be a bit safer than TNC due to slower speeds.

Requirement	PRT	BRT	LRT	BikeRT	TNC	A-Shuttles
Safe and Secure	5	2	3	4	2	3

Reliable

Transit level of service A is equivalent to one trip failing for every forty trips (97.5% reliability). This is not considered sufficient since almost all workshop participants ranked reliability very high. A better goal is to come close to the reliability displayed by airport automated people movers. A goal two-and-a-half times better that transit level of service A is proposed.

<u>Goal</u>

99.0% on-time reliability

<u>Meeting the Goal</u>

PRT: Modern PRT systems in public service are achieving availabilities more than 99.5%.

BRT: Dedicated lanes and signal prioritization add to reliability while in-line stations and deployment of wheelchair ramps (if needed) as well as portions of the trip in or crossing mixed traffic detract from it.

LRT: Dedicated rights of way and crossing priority add to reliability while in-line stations and deployment of wheelchair ramps (if needed) as well as portions of the trip in or crossing mixed traffic detract from it.

BikeRT: Encountering lots of slow riders could detract from reliability as could intersection backups.

TNC: TNC is susceptible to congestion and thus trip times could vary greatly.

A-shuttles: Stopping to pick up and drop off passengers on demand will add to trip variability. If deployed for short trips in less congested areas, they will be less susceptible to congestion-related delays.

Requirement	PRT	BRT	LRT	BikeRT	TNC	A-Shuttles
Reliable	5	3	4	3	2	3

Cost-effective

The holy grail of cost effectiveness is a system that pays for its own capital and operating costs through its own revenues. Transit systems in the US typically cannot even pay for their own operating costs, let alone capital costs, through fare-box revenues. In recent years the US Highway Trust Fund has needed significant transfers of general revenues to remain solvent and even then, funds are insufficient to adequately maintain and expand the highway infrastructure.

Goal

Revenues cover capital plus operating costs

Meeting the Goal

PRT: A recent study (PRT Consulting, Inc. 2018) found a large PRT deployment could cover its own capital and operating costs (totaling around $4 per passenger trip) in a community with a population density of under 2,500 per square mile. Deployments in higher density areas where ridesharing can be effective will be more cost-effective.

BRT: Based on the FTA's list of BRT projects under consideration for funding, the average total cost per passenger trip is around $6.

LRT: Based on the FTA's list of LRT projects under consideration for funding, the average total cost per passenger trip is around $22.

BikeRT: While the operating costs per passenger will be very low, the infrastructure costs will be relatively high due mostly to expected low capacity, higher per-square-foot loading than PRT and the need to cover guideways.

TNC and A-shuttles: While TNC can pay for itself, A-shuttles typically will not and these modes are not contributing to the Highway Trust Fund sufficiently to keep it solvent.

Requirement	PRT	BRT	LRT	BikeRT	TNC	A-Shuttles
Cost-Effective	4	3	1	3	4	2

Reduces VMT and congestion

This reflects the ability of a solution to attract riders from surface modes in significant numbers and to adequately accommodate that level of demand. Key factors, in addition to being safe and reliable with low costs, include being convenient and comfortable with short walking distances and waiting times coupled with high-frequency service and short travel times with no transfers.

Goal

Significantly reduce surface traffic and/or the space used by surface traffic

Meeting the Goal

PRT: Emerging PRT systems from several suppliers are being developed to provide capacities up to 20,000 passengers per hour per direction at speeds up to 60 mph (40 mph average) while having stations every one-half mile (Transit Control Solutions, 2018). High capacities, equivalent to about seven freeway lanes, are enabled by using six-passenger vehicles, many of which are filled using ride-sharing techniques facilitated by station operations like the one shown here[1]. Walking distances are short, as are waiting times. Transfers are not required. Everyone gets a seat. Numerous studies by various researchers around the world (see Figure 7) have found that extensive PRT deployments will usually increase transit mode share by far more than double. Since PRT is usually elevated, this results in an immediate reduction of surface traffic.

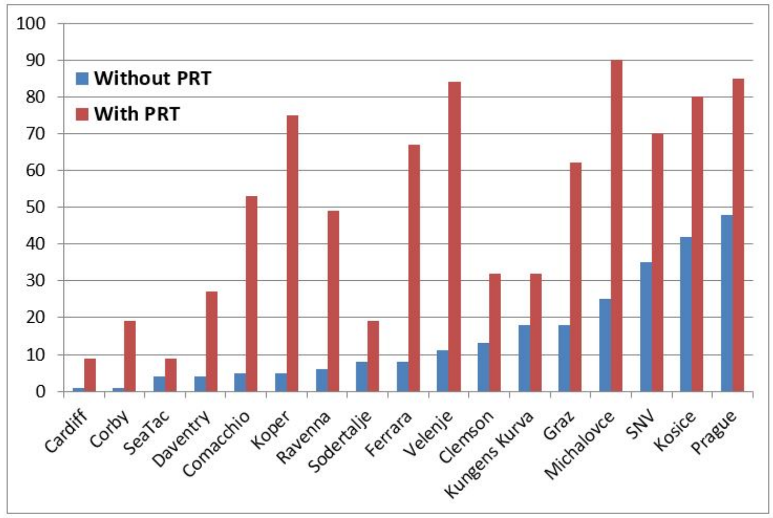

Figure 7. Transit Mode Share With and Without PRT

BRT/LRT: BRT/LRT can reduce the surface space used for traffic. A BRT/LRT lane could carry two or three times the number of passengers in a freeway lane and only take up one and a half times as much space. In-line stations result in slow average service speeds for these modes (6 to 34 mph). This combined with the need for transfers and relatively high station spacing makes them less likely than PRT to attract significant numbers of passengers.

BikeRT: Like PRT, the passengers diverted to this mode are immediately removed from surface traffic. However, the ability to divert passengers is questionable (especially for longer trips) as is the capacity to accommodate them.

TNC: Unless ways are found to increase vehicle occupancies through ride sharing, these modes are likely to induce trips (including empty-vehicle trips) and increase both VMT and congestion.

A-shuttles: A-shuttles are not anticipated to do well in congested environments unless they are operated like BRT. They could provide some relief in areas with light congestion.

Requirement	PRT	BRT	LRT	BikeRT	TNC	A-Shuttles
Reduces VMT & Congestion	4	3	3	2	1	2

[1] https://www.youtube.com/watch?v=dXyBJ_nyh4M

Sustainable

Sustainability is most often defined as meeting the needs of the present without compromising the ability of future generations to meet theirs. It has three main pillars: economic, environmental, and social. These three pillars are informally referred to as profits, planet and people. Since economic impacts have been accounted for under cost-effectiveness, this section focuses on environmental impacts (mostly energy use and emissions) and social impacts (the ability to have tiered service levels allowing a significant range of fare prices). Note that the ability to have widespread service areas is addressed separately.

<u>Goal</u>

Low energy use and emissions per vehicle mile combined with tiered fares/service levels

<u>Meeting the goal</u>

PRT: PRT uses about one third the energy per passenger mile of most other systems (Advanced Transit Association, 2018). There are no point-of-use emissions and guideways are suitable for supporting solar panels large enough to power the system. PRT passengers could pay per vehicle to get exclusive use (for themselves and their traveling companions) coupled with no waiting and a nonstop trip. Alternatively, they could pay a lower per-ride rate and wait up to (say) five minutes to share a vehicle and have a possible intermediate stop or two. Economically-challenged riders could choose to pay even less and wait longer (say up to 15 minutes). In addition to the social benefits offered, this tiered fare structure is expected to significantly increase vehicle occupancy.

BRT/LRT: Both systems have low energy use when full of passengers but are obliged to keep running relatively empty large vehicles during off-peak hours. Some BRT systems are moving to electric propulsion. There is some ability to provide reduced fares but little or no ability to match the fares to service levels.

BikeRT: This mode obviously has the lowest energy use and emissions. There is some ability to provide reduced fares but no ability to match the fares to service levels.

TNC: This mode tends to have higher energy use and emissions although more future use of electric propulsion is likely. Lower fares in return for sharing rides are possible.

A-shuttles: A-shuttle energy use may be good during peak periods, but this is likely to be offset by low off-peak passenger loads. Point-of-use emissions will be low. There is some ability for TNCs to provide reduced fares but limited ability to match the fares to service levels.

Requirement	PRT	BRT	LRT	BikeRT	TNC	A-Shuttles
Sustainable	5	2	3	4	2	2

ADA Compliant

This requirement requires compliance with the Americans with Disabilities Act or similar regulations. Most of the score given each mode relates simply to whether it typically complies. However, some consideration has also been given to ease of use. BRT and LRT are quite difficult for newcomers (disabled or not) to use, requiring knowledge of timetables, routes, transfers etc. The other modes typically require only knowledge of the name of the destination station.

Goal

Compliance with ADA or similar plus ease of use

Meeting the goal

PRT: All systems comply with ADA or the equivalent. The name of the destination station is all that needs be known.

BRT/LRT: While these systems are typically ADA compliant, they are also typically not easy for newcomers to use and can often require transfers.

BikeRT/TNC/: These systems are typically not ADA compliant but are relatively easy to understand and use.

A-shuttles: These systems should be ADA compliant and are relatively easy to understand and use

Requirement	PRT	BRT	LRT	BikeRT	TNC	A-Shuttles
ADA Compliant	5	4	4	2	2	5

Widespread Service Area

This means that stations/stops are close together and are spread throughout the community rather than being confined to campuses or corridors.

Goal

90% of the community population is within one-half mile walking distance of a station/stop.

Meeting the goal

PRT/BikeRT: These systems are typically laid out as a series of one-way (or two-way in very dense communities) interconnecting loops with guideways spaced about one-half mile apart. Station spacing along guideways is also about one-half mile resulting in stations scattered throughout the service area about one-half mile apart. This results in most people living and working within about one-quarter mile of a station as the crow flies. Thus, these systems should result in the above goal being met with the exception that BikeRT systems have more limited range.

BRT/LRT: Not only are these systems typically confined to corridors but the station spacing along the corridors is usually in excess of one-half mile.

TNC: TNC will typically have door-to-door access to the entire service area.

A-shuttles: While these systems will typically have frequent stops, their service areas are expected to be small.

Requirement	PRT	BRT	LRT	BikeRT	TNC	A-Shuttles
Widespread Service Area	5	2	2	4	5	2

Summary of Results

Table 1 summarizes the above results and shows the total scores.

Table 1. Summary of Results

Requirement	PRT	BRT	LRT	BikeRT	TNC	A-Shuttles
Safe and Secure	5	2	3	4	2	3
Reliable	5	3	4	3	2	3
Cost-Effective	4	3	1	3	4	2
Reduces VMT & Congestion	4	3	3	2	1	2
Sustainable	5	2	3	4	2	2
ADA Compliant	5	4	4	2	2	5
Widespread Service Area	5	2	2	4	5	2
TOTALS	33	19	20	22	18	19

While the results indicate PRT stands head and shoulders above the other modes, the differences between the other modes are relatively insignificant. This may indicate that, absent a PRT solution, a mix of the other modes, with the mode being chosen to suit the needs of each particular application, is about as good as we can expect to do. In other words, absent a PRT-like solution, we can expect surface transportation to continue to get worse.

COMBINED SOLUTIONS

There is no silver bullet and transportation of the future will no doubt involve a mix of solutions. Perhaps another requirement considered should have been *Ability to Integrate with Other Modes.* In this regard, it is possible that driverless TNC and A-shuttles could overcome one major shortcoming (reduces congestion) by incorporating elevated guideways to "jump over" congested areas. This may help but it will do little to address the important issues of safety, reliability, sustainability and ADA compliance. These require vehicles, guideways and stations designed to operate together *as a system*. In other words. TNC and A-shuttles with elevated guideways will struggle to achieve the safety, reliability, sustainability and ADA compliance of PRT.

CONCLUSIONS

The results obtained here point to PRT being the solution that comes closest to meeting the needs of the traveling public as they have been expressed in public workshops around the country.

The requirements and scoring presented here can certainly be questioned. However, the basic process is believed to be quite sound. Those questioning these results are encouraged to develop their own list of requirements and score their preferred solutions against those requirements in a similar manner. The more we undertake thoughtful analyses of alternative solutions, the more we are likely to hone in on the best ways to move forward.

BIBLIOGRAPHY

Advanced Transit Association. (2018) http://www.advancedtransit.org/advanced-transit/prt-characteristics/

PRT Consulting, Inc. (2018) *Automated Transit Network Feasibility Study for Clemson, Greenville and Mauldin.* http://www.advancedtransit.org/wp-content/uploads/2018/10/20180904-GPATS-ATN-Feasibility-Study.pdf

Transit Control Solutions. (2018) www.transitcontrolsolutions.com