Understanding Podways and PRT

by Transit X

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Understanding Podways/PRT

1. Concept overview

By analogy, PRT (Personal Rapid Transit) is like a fleet of autonomous taxis operating on exclusive, grade-separated, one-lane "road" (guideway) where a "taxi" can only stop at a taxi stand. To date, PRT implementations have been more similar to a light-rail lines or circulators and not for roadway-like network with junctions and intersections.

Transit X has developed a proprietary PRT system called a “podway.” It has six unique features that make it unique compared to other PRT systems:

1. **Factory-built** — high-speed automation line for beams and posts achieves **low cost**
2. **Lifts** — low cost stops to enter pods at ground level **without using land area**
3. **Utility integration** — podways can **replace utility poles**, lines, and street lighting
4. **Goods** — automated **transport of freight** and packages to businesses and loading docks
5. **High Speed** — travel over longer distances alongside highways at 242 km/h
6. **Trains** — up to 6 pods can dynamically form pod trains to achieve **high capacity**

These unique features enable podways to achieve the low cost, high capacity, and high convenience that has eluded the PRT industry for decades.

A 2-minute video at transitx.com/video and a 1-minute animation at transitx.com/city provide a good overview of a podway.

2. Pros and Cons of PRT

Advocates of PRT have been promoting the following advantages of PRT for over 50 years: faster and safer trips, higher capacity than roads, more efficient than cars, and cost much more than roadways. However, PRT is not as convenient as a car, has lower capacity than a subway, and costs much more than roadways. While PRT stations are smaller than a subway station, they are still quite large and do not easily fit into an existing city or suburb. These are severe limitations of PRT.

Proponents of PRT argue that when the first PRT system is built, the advantages will be clear and hundreds (or thousands) of PRT networks will be built. But to date, only small and simple PRT networks have been built. There are no large-scale, roadway-like PRT networks with intersections.

No Large PRT networks

Given that the PRT concept was first proposed 70 years ago, and that no large-scale PRT networks are currently in operation, the key question is: "Why are there no large PRT networks?"

Our analysis concludes there are 8 major reasons. We refer to them as the four C's (Cost, Capacity, Convenience, Consultants) and the four F's (Financing, Freight, Fit, and Fear).

Cost

While a PRT is cost-competitive with light rail, it is more costly than a new roadway. PRT is fully automated and therefore needs a dedicated infrastructure that is grade-separated (elevated or underground). Bridges and tunnels are much more costly to build than surface roadways. The higher the cost of building infrastructure, the higher the population density is needed to be economically viable. PRT infrastructure is too costly to service a low-density area such as suburbs and lacks high capacity to serve high density cities. Also, because PRT is grade separated, the system needs a way to get people up and down from a platform. This is accomplished with elevators and stairs — both of which add cost and use significant amounts of land.

Convenience

A car provides curb-to-curb trips. PRT supports only station-to-station trips within a geographic region. While PRT stations can be more convenient than mass transit or gondolas, PRT lacks the convenience to completely solve the "last mile" problem. Adding more stations to make PRT convenient is not practical because of a station's significant cost and land use. Obviously, cars on roadways don't need stations — they can pull over to the side of a road for pickup or drop off.

Capacity

PRT does not have the capacity to replace heavy rail or subways, and PRT is too expensive to be economically viable for low density areas. This restricts the potential of PRT to special-purpose and medium-capacity applications.

Consultants

An independent transportation consulting firm is usually hired by a government to lead the acquisition and evaluation process. While these firms are experts in conventional transportation modes, there is a general lack of familiarity with PRT or Podcar Technology. The old adage "No one got fired for going with IBM" applies here. A consulting firm can easily dismiss innovative solutions by saying "we would not recommend it because it is not operational anywhere”. This reasoning limits solutions to only incremental improvements.

Fit

When a city or suburb is developed, land is allocated for roads and parking — but not for a PRT network. Attempting to retrofit an extensive PRT network into an existing built environment is extremely challenging — particularly if PRT has a large footprint. PRT has not achieved widespread commercial success, in part because its large stations and large guideways have made it difficult to retrofit into an urban or suburban environment.

Funding

Unlike roadways and railways, PRT systems are proprietary and do not qualify for matching federal and state funds. No government will fund a PRT project. A large PRT network is needed to offer the convenience of a car, but the capital cost of such a network would be prohibitive for governments to fund and not viable for private financing. PRT projects can't raise financing from sources of private capital because of the high capital costs and perception of high risk. Commercial lenders are not able to provide low-cost debt financing for a PRT system because there are no large-scale PRT systems in operation.

Fear

Municipal governments are accountable to the public when spending public funds. That makes them fiscally conservative and risk adverse. Most civic leaders would avoid PRT because there are no large-scale PRT systems in operation and only a handful of small PRT systems around the world. PRT suffers from a perception of high risk because it is seen as "new" or "different". Staying with the status quo has significant risks from crashes, flooding, air pollution, water pollution, maintenance costs, carbon emissions, and traffic congestion — but those risks are often deemed "unavoidable" even if a PRT could mitigate those risks.

Freight

On roadways, moving freight is just as important as moving people, but PRT systems have not been designed for freight transport. Without freight revenue, financing large PRT networks are more difficult. Also, if PRT does not carry freight, then it can not replace roadways.

3. Evaluating PRT & Podway

PRT

There are four operational PRT systems and there have been over 70 startups developing PRT systems over the past 50 years. A webpage listing many PRT systems:

http://faculty.washington.edu/jbs/itrans/prtquick.htm

> Source: Jerry Schneider, Prof. Emeritus, Urban Planning/Civil Engineering at Innovative Transportation Technologies.

PRT Consulting maintains a list of PRT vendors with links to their websites:

https://prtconsulting.com/personal-rapid-transit-vendors.html

2getthere

ModuTram

Tubenet Transit

Ultra Global

Ultra PRT

Ultra Fairwood

Vectus

PRT Consulting's criteria for a PRT Vendor:

- Vehicle operation is fully automated
- Small vehicles carrying 30 or less passengers
- May bypass intermediate stations
- Operates on-demand (unscheduled)

Operational PRT systems

Location	Name and Vendor	Route (km)	Vehicles	Service Years
Morgantown, West Virginia	Morgantown PRT	5.8	70	1975-present
London Heathrow Airport	ULTra	3.8	21	2011-present
Masdar City, UAE	2getthere	1.8	10	2010-present
Suncheon, South Korea	Vectus	4.6	40	2014-present
Raytheon, Massachusetts (safety certified)	PRT 2000	1.5	3	1995-1997

Transit X Podway

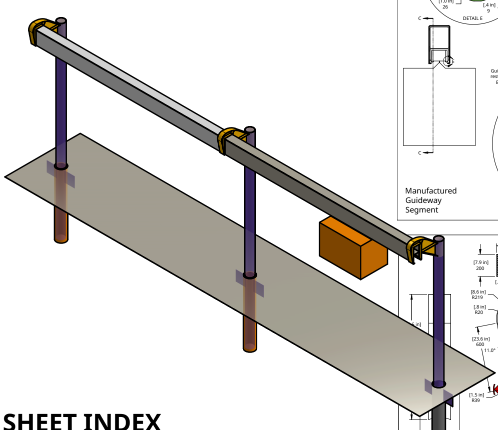
Transit X builds and operates podways. It has commitments from governments and sources of private capital to build dozens of projects around the world. A short podway was installed 30 miles from Boston, Massachusetts in 2021, that proved the engineering, cost, manufacturability,

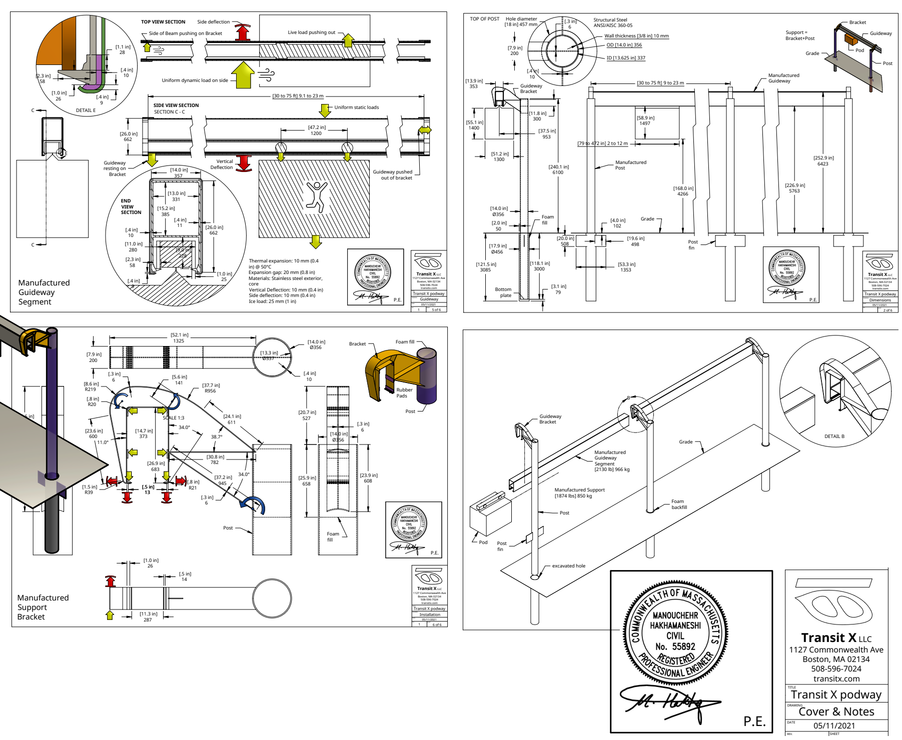
First Pilot Podway

and installation of the podway's infrastructure. The system is now used for demonstrations and testing. All of the core podway technologies have been safely used in other operational systems for decades. The project’s turnkey contracts are with large and reputable firms prepared to guarantee to deliver on-time and on-budget. Project partners have built and operated fully automated transit systems. Projects are fully bonded and service levels are guaranteed.

First Pilot Podway installation and testing

Transit X
Manufactured Podway





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1. Cover sheet
2. Dimensions
3. Loads & Analysis
4. Installation
5. Guideway
6. Bracket

Evaluation Goals

We propose the following list of goals for comparing transportation modes. When comparing very different modes across a variety of traits, we used a relative scale from -2 to 2 with the mid point at 0 (meets goal). It is like "grading on a curve."

SERVICE

How well would a population be serviced within that region?

Population served

Goal: at least 70% of population is Accessible (see below)

Rationale: Cars can service 100% of the population because everyone is near a roadway. A PRT system should be able to service a "super majority" of the population.

Trip speed

Goal: Average local trip speed of 32 km/h (20 mph) for at least 90% of all trips

A local trip is one that starts and ends within the region. Trip duration and length is measured curb-to-curb from origin to destination. An average speed is length divided by duration, where length is measured by travel distance by roadways and trip duration includes all walking and waiting times from starting curb to ending curb. Traffic congestion reduces trip speed.

Rationale: During peak commuting times, an average trip speed in an urban environment is often slower than 24 km/h (15 mph), when you include time to find parking. An electric bike can travel at 32 km/h (20 mph). A PRT system that provides fast, non-stop travel, would expect people to walk (or bike/scooter) a few minutes at one or both ends. PRT line capacity and boarding capacity should be sufficient to minimize any waiting at stations or on the guideway.

Accessible

Goal: at least 95% of the population

Those with atypical mobility needs (wheelchair, walker, assistant, stroller, cart, etc.) are included. Infants and children up to 5 years old may need a guardian/attendant. Those with atypical language, vision and cognitive skills should all be accommodated. The PRT should also be available for those needing emergency transport.

Rationale: A handicap-accessible public transit system can accommodate 85% of the population. A typical car could accommodate 95% of the population, and 99% of the population if a car seat was available for children and an assistant was available for those needing one. Vans are often used to accommodate a small percentage of the population using heavier electric wheelchairs and those with special needs. An electric bicycle might accommodate 50% of the population for relatively short trips.

Available

Goal: 24 hours a day, every day, with at least 98% availability.

Rationale: Most public transit systems do not operate 24 hours a day. Some operate only during weekdays. A personal car or bicycle is always available (except when being serviced). PRT should achieve high availability and only need to shut down short sections for scheduled maintenance windows.

Equitable

Goal: A fare structure needs to provide equitable and affordable transportation.

Rationale: The average household income is $63,000. An average electric car costs $64,000 and the annual cost of owning or leasing an electric car is about $10,000. A low-end electric bicycle costs about $1000 and average annual cost of owning an electric bike is about $300. A 12-month pass on MARTA costs $1,140 and is mostly useful for commuting, not errands. Taking a taxi three times per week would cost at least $4,000 annually. Public transit fares are often reduced for seniors, students, and children. For most passengers, the price of a trip should be competitive with public transit fares (that are heavily subsidized).

Comfort

Goal: At least as good as a taxi ride.

Rationale: For most of the length of any trip, passengers should be seated in a temperature-controlled, private space. At the ends of a trip, a passenger may need to walk with an umbrella. A passenger should be free to use an electronic device or talk on the phone.

Safe

Goal: At least ten times safer than trips via taxi with a driver.

Rationale: Personal safety is a major concern for many people who take public transit or a taxi. Safety concerns include crashes or verbal and physical assaults during trips. Car drivers may also be a victim of car-jacking, road rage, or assaults in parking lots.

Mixed Vehicles

Goal: The system supports a variety of vehicle types including being capable of transporting at least 90% of freight and packages.

Rationale: A roadway and highway infrastructure supports many different uses and vehicle types, only limited by design loads of bridges, hazardous material classifications, and turning radii on intersections. A transportation system — particularly a transportation infrastructure — should be general purpose like a roadway, capable of supporting many types of loads.

ENVIRONMENTAL IMPACT

How will a system improve the environment?

Land use

Goal: Additional land use, including parked vehicles and depots, should need less than 1% of total land area in the region.

Rationale: Roadways and associated transportation infrastructure (parking lots, gas stations, repair shops, etc) now occupy at least 40% of the total land area of a typical city. If a new transportation infrastructure is built, it should need a minimal amount of land and should not need to acquire land via eminent domain. If using existing travel lanes, the system should allow continued use of roadways by existing vehicles without degrading service levels. Should be able to limit expansion of roadways and ideally can reduce roadway land use over time.

Noise level

Goal: Lower than 65 dBA from a pedestrian location (6 feet above sidewalk, closest to system)

Rationale: Noise from highways is about 80 dBA. Cars on a street traveling at 56 km/h (35 mph) generate about 70 dBA, not including peak sounds such as sirens, car alarms, and passing buses. Solution should reduce overall noise levels.

Pollution

Goal: System powered exclusively by clean and renewable energy sources. Embodied energy of system — including fixed infrastructure — should be less than the embodied energy of the electric vehicles that would otherwise be needed.

Rationale: Need to rapidly transition to a green energy economy. Passing NEPA and other environmental regulations will be easier and faster if the system has a significantly lower environmental impact than alternatives.

Resilient

Goal: More resilient to extreme environmental conditions than roadways or railways.

Rationale: The system should continue to operate in atypical environmental conditions such as fog, high winds, snow, flooding, ice storms, and extreme heat.

IMPLEMENTATION

During implementation, how much would people and businesses be impacted?

Disruption

Goal: Less disruption than re-paving a roadway

Rationale: People are familiar with the disruption of re-paving a roadway, so ideally, disruption should be less than that. Construction should not significantly disrupt businesses or neighborhoods.

Short timeframe

Goal: Implementation should start within 12 months of Notice to Proceed and be operational within 24 months.

Rationale: Longer projects have higher risk because there are elections, leadership changes, and infrastructure changes that all contribute to potential disruptions during implementation.

ECONOMIC IMPACT

What will be the economic and financial impact to businesses and residents?

Government burden

Goal: No financial burden to government for either capital costs or subsidizing operations.

Rationale: All costs of construction and operations are expected to be funded from private and commercial sources. Government has no allocated funds or budget and does not expect to have one.

Jobs

Goal: Create more local jobs than would be displaced.

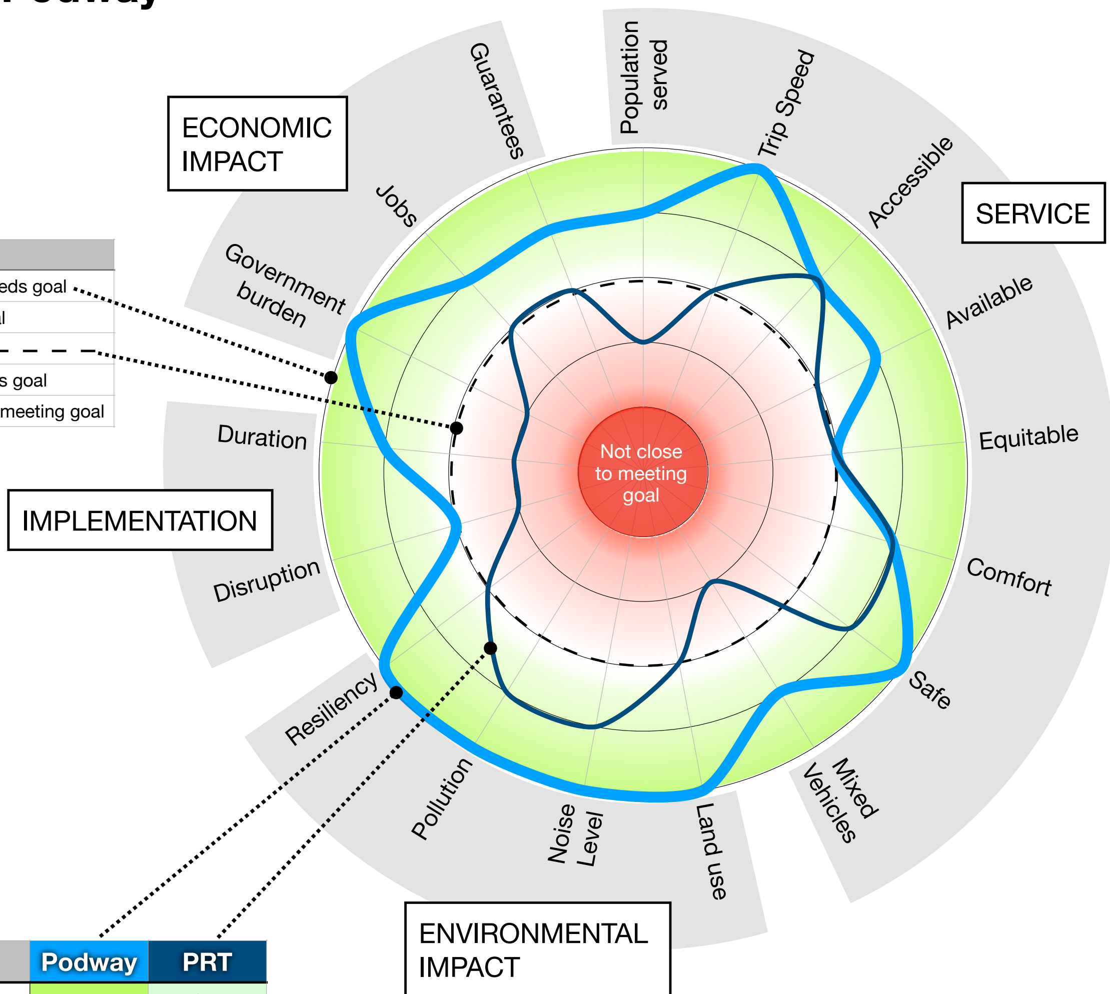
Rationale: People who may be displaced by proposed system should be provided new job opportunities and training for those jobs.

Guarantees

Goal: The government should not be at risk — financial or liability — for any problems due to implementing the system. A provider should pay financial penalties if minimum service levels are not reached. Sufficient funds should be held in reserve, along with a performance bond, so that if the system fails to work, any fixed infrastructure may be removed and returned to pre-existing conditions without cost to the government.

Evaluating
PRT and Podway

Score	Definition
2	Greatly exceeds goal
1	Exceeds goal
0	Meets goal
-1	Almost meets goal
-2	Not close to meeting goal



Goals ⬇	Podway	PRT
SERVICE	**1.1**	**0.1**
Population served	1	-1
Trip Speed	2	0
Accessible	1	1
Available	1	0
Equitable	0	0
Comfort	1	1
Safe	2	1
Mixed Vehicles	1	-1
ENVIRONMENTAL IMPAC	**2.0**	**0.5**
Land use	2	0
Noise Level	2	1
Pollution	2	1
Resiliency	2	0
IMPLEMENTATION	**0.5**	**-1.0**
Disruption	0	-1
Duration	1	-1
ECONOMIC IMPACT	**1.3**	**-0.3**
Government burden	2	-1
Jobs	1	0
Guarantees	1	0
AVERAGE	**1.3**	**0.0**

4. Rights-of-way

Building a new transportation infrastructure is a huge challenge in most locations. Building highways, light rail, and high-speed rail end up taking decades to implement and often go over budget. Public infrastructure projects in the U.S. are well known for being costly and going over budget. One root cause is the difficulty in securing land and/or rights-of-way across an entire region. Any proposed PRT project needs a plan to address these issues.

Securing Rights-of-way

When major infrastructure was first constructed in the U.S., the railroads were granted land and wide and straight rights-of-way as an inducement to build railway infrastructure. Today, there is an overlapping patchwork of easements, rights-of-way, private land ownership by companies and individuals, and public lands from multiple government authorities. Any PRT project would need to somehow fit in — and that would be a major challenge because PRT uses significant land for stations, junctions, parking, guideway superstructure and substructure. Attempting to buy the land — even assuming using the power of eminent domain — would likely not work. A podway solves these issues by fitting within an existing utility corridor in the public right-of-way that is managed by a single right-of-way owner.

Network Effect

The value of a networks exponentially increases with the size of the network.

Roadways, railways, international shipping, and aircraft networks are fully connected networks. For example, a driveway in a small town in Maine is connected over the roadway networks to a local road in San Diego. You can take a plane from an airport in Alaska and — with multiple hops — reach any other airport in the world. A train car on a railway on the East coast can reach any railway on the West coast.

Other transportation networks such as light rail, subways, buses, high speed rail, monorails, PRT, gondolas, taxis, and sidewalks are examples of local networks confined to a local geography. Those local transportation networks connect to other large networks (long-distance) as well as individual businesses and housing using the road network. Cars and trucks can travel from curb-to-curb in a "single seat". Other forms of transportation must rely on slow, multi-modal trips, with the roadway infrastructure providing the means to reach a final location.

Why is this important? Because small networks accommodate many fewer trips than large networks because of powerful network effects — particularly if the small, special-purpose transportation network (such as PRT) covers the same region as the road network. It's the reason why public transit accounts for only 1% of trips in the U.S. and the vast majority of trips use a personal car. A small PRT network is likely not viable while a larger one may be. There is no reason for the government to request a small PRT system when government funding is not at risk.

Podways in Cities

If a podway needs high ridership that can only be accomplished by servicing the major centers of population (cities), and a County can only provide rights-of-way on county roads, how can a podway network achieve the ridership necessary to be financially viable? Because when the county shows their commitment to a new transportation infrastructure that connects all the cities, then at least two cities will also move forward with a commitment to that infrastructure. Once two cities move forward, other cities will follow because of their fear of missing out. In addition, one or more abutting counties will then want to expand the infrastructure to their region.

Single RoW owner

A government entity — whether town, city, county, state, or national — usually controls the rights-of-way along specific roadways and highway. Often these rights-of-way connect to a larger network. A separate utility company — private or municipal — usually has an agreement with a government authority for the necessary rights-of-way easements to provide a service for the common good. Utilities can install and maintain poles, lines, and equipment without significant environment review or approval from abutters.

A podway must go along roadways to provide convenient access to the same locations as the roadway network. Even if other land was available for a new transportation infrastructure — along an unused railway, for example — it wouldn't be convenient to existing housing, businesses and other destinations. Our environment has been designed and built around the car and roadway network, so the podway too must co-exist along the roadway for existing cities.

A project that only needs the rights-of-way from one authority will dramatically reduce the cost and time for a project's development work. The complexity of acquiring rights-of-way is proportional to the number of right-of-way owners. A project can not secure private financing until it has a binding agreement for rights-of-way across the region.

Fit within Public RoW

Most areas in the U.S. are heavily dependent upon roads and cars. Residents cannot fathom how they would live without their car. Both businesses and residents would object to any proposal that reduces travel lanes or parking for cars. This happens now when there is a proposal to allocate a dedicated travel lane for use by buses or bikes.

A podway would significantly reduce the demand on roadway lanes and parking, but the public would strongly object to a new infrastructure that takes land away from personal cars. To achieve public support for a podway project, the podway must: (1) fit entirely within the public road rights-of-way, and (2) not reduce travel lanes or parking spaces.

The roadway right-of-way is already crowded with guard rails, median barriers, trees, shoulders, bike lanes, travel lanes, parking, roadway intersections, bridges, overpasses, street lighting, signage, traffic signals, and utilities. A PRT system would need to fit within the roadway rights-of-way, including its columns, vehicles, junctions, and stations that take up land and space.

The podway's infrastructure was designed to fit alongside a roadway within a utility corridor without taking space from roadway lanes or parking, and without modification to existing infrastructure including bridges and roadways. A podway has no large stations and a podway stop has a landing zone half the size of a parking space. A podway's support structure consists of small diameter (350 mm) steel posts that are the diameter of utility poles. The guideway has a small cross sectional area (350 mm x 660 mm) that is smaller than the space occupied by utility lines.

Utility Integration

Even though the podway infrastructure fits within a utility corridor, that space is occupied by utility lines and poles. To resolve a potential conflict for rights-of-way, a podway is designed to integrate all utilities within the podway's infrastructure. A hollow upper cavity in the guideway, called a utility raceway, can house a dozen utility conduits. Hollow posts allow utility lines to run inside the posts and underground to service points on buildings.

A podway company would enter into an agreement with the local electric company and telecommunication providers. The podway company would need utility-like rights to install infrastructure for the public good within the public right-of-way, while bypassing objections by abutters.

Crossing Interstate Corridors

A county can request approval from another government authority (state or city) when crossing a roadway or highway.

Aesthetics

The visual aesthetics are very important. Despite the ugly appearance of wide roads, parked cars, large parking lots, and overhead utility lines, people are accustomed to them. Many people will consider *any* new infrastructure as being ugly. For example, the Eiffel Tower was considered an eyesore by Parisians when it was first built — until it became an iconic symbol of Paris. Buildings and infrastructure can both big and beautiful. Boston spent $23 billion to move a 4-mile elevated highway below ground, but most photos and images of Boston now feature the Zakim Bridge — an elevated structure.

There are ways in which the infrastructure can be customized to fit a particular style or aesthetic. For example, support posts can have custom detailing — like customized street light poles. The guideways and posts can also be a canvas for public art.

We expect that a small percentage of residents will object to the podway because they deem it "ugly", when it likely is more about being "different". Visualizations can help assuage concerns about the podway's visual impact and show how the podway can help transition to an overall improved quality of life.

Summary

A proposed system needs an approach for securing rights-of-way. A podway is designed to have little to no dedicated footprint, fit within a utility corridor along public roadways, and integrate utilities within its infrastructure. Only a system that is similar to roadways has the potential to supplant roadways.

5. Evaluating Transportation Types

Why are cars so popular?

Despite the high cost, crashes, congestion, and pollution that cars are responsible for, they account for the vast majority of trips in the U.S. Why? Because people value direct, comfortable, private-party trips going anywhere at anytime.

Why is public transit so unpopular?

Across the U.S., public transit in used in 5% of commutes and 1% of all trips. Why are buses and trains so unpopular? Because public transit is either not available, not convenient, infrequent service, slow trips, crowded, negative perception, painful transfers, limited hours, unreliable, hard to use, and passengers may not feel safe. Buses and trains can never be popular because large capacity vehicles must run on a fixed schedule and fixed route to serve commuters. On-demand service is not a viable option with large-capacity vehicles.

Transportation Types

An evaluation matrix with an associated radar plot is shown for PRT, podways, and the best-in-class examples from the most common types of transportation. Each row represents a goal defined in section 3.

Legend: -2 (Red) = far below goal, -1 (Pink) = not far below goal, 0 (white with green tint) = meets goal, 1 (light green) = exceeds goal, and 2 (green) = greatly exceeds goal.

Car

Includes personally used 4-wheeled vehicles with less than 8 seats. Also includes trucks for transporting goods.

Best-in-class example: autonomous, electric vehicle that is charged from renewable energy sources.

The vast majority of trips in the United States are in a personal car because it is available 24/7, and provides curb-to-curb transportation in the comfort of a private cabin. Average capital cost of $60K per vehicle and an annual cost of $10K. Traffic tickets and parking costs can be substantial in urban environments. Relatively low capacity per travel lane — between 1,000 to 2,000 passengers per hour assuming 1.1 passengers per vehicle. Walking time from parking lot to final destination is assumes to be 1-2 minutes. During commuting periods, travel speed is substantial reduced due to congestion.

Taxi

Includes 4-wheeled vehicles with less than 15 seats that includes taxis as well as ride-hailing services such as Uber and Lyft.

Best-in-class example: autonomous, electric vehicle that is charged from renewable energy sources.

Taxi shares most of the attributes of cars, but the cost per trip for a passenger makes it unaffordable for daily commutes. During peak times, taxis may be unavailable, very expensive, or have long wait times. Up to 1/2 of distance travelled are without passengers (dead-head).

Much more available in dense urban environments than suburbs. Wait times can vary from a few minutes to more than 20 minutes.

Bike and micro-transit

Includes manual bicycles, electric bicycles, electric scooters and other single-user lightweight (<50 kg) vehicles with fewer than 4 wheels.

Best-in-class example: low-cost, personally owned electric bike or scooter

Per unit capital cost between $400 and $3000. May be personally owned or shared. Shared vehicles may be at specific docks, or dock-less. Requires manually re-balancing supply of vehicles using vans. Vehicles have a relatively short lifespan (< 18 months) and relatively high charges per km.

Bus and BRT

Includes vehicles with over 15 seats and more than 4 wheels.

Best-in-class example: electric bus charged with renewable energy and operating with 5 minute headways.

Fixed route and fixed schedule. Along the route, there may be bus stops on every other block. Capital cost of $300K per vehicle with capacity from 40 to 80 passengers. Bus stops may or may not be semi-protected and may have seating. Buses generally have poor ride quality and potentially crowded conditions and standing room only. Most of the time, vehicles occupancy is less than 10% of maximum capacity. Wait times generally vary between 5 minutes and 60 minutes. Transfers often needed and very slow curb-to-curb trip speed when including walking to stops, waiting for bus, stopping at bus stops and transfers. Requires central maintenance facility and parking. Operates along major roads and streets. Has limited hours of operation.

Light Rail & LRT

Includes large-capacity vehicles operating on standard gauge tracks

Best-in-class example: electric powered via induction coils from renewable energy sources and operating with 3 minute headways.

Fixed route and fixed schedule. Needs dedicated rights-of-way at grade level. $1M+ capital cost per vehicle and $50M+ per km for fixed infrastructure. Trains with 2 to 4 cars can carry 150 to 300 passengers.

Stations every 400 meters (or more) if at grade. New train cars are handicap accessible. Acceptable ride quality but potentially crowded conditions with standing-room only. Higher line capacity than buses and lower capacity than heavy rail. Majority of time, vehicles carrying less than 10% of passenger capacity. Wait time varies by route between 5 minutes and 15 minutes. Exclusive right-of-way may avoid roadway congestion, but stops, signals, and transfers reduce light rail's average trip speed. Transfers are often needed to buses and that reduces curb-to-curb trip speed — including time to walk to stops, wait for trains, and stopping at intermediate stations or stops. Requires central maintenance facility and parking. Generally operates on circulator or hub-and-spoke layouts. Limited hours of operation. High capital costs and high operational costs limit size of networks to cover major commuting routes.

Flying

Includes flying vehicles with up to 6 passengers

Best-in-class example: autonomous, light-weight, with electric engines powered by batteries. Vertical take-off and landing (VTOL).

There are dozens of companies working on lightweight autonomous aircraft to carry both people and goods. Many have flown prototypes. Expensive to buy and operate. Biggest issues are safety, noise, and lack of suitable landing areas. Low capacity.

Podway

Includes automated pods carrying up to 6 adults on dedicated, grade-separated guideway. Also fits definition of ATN and PRT.

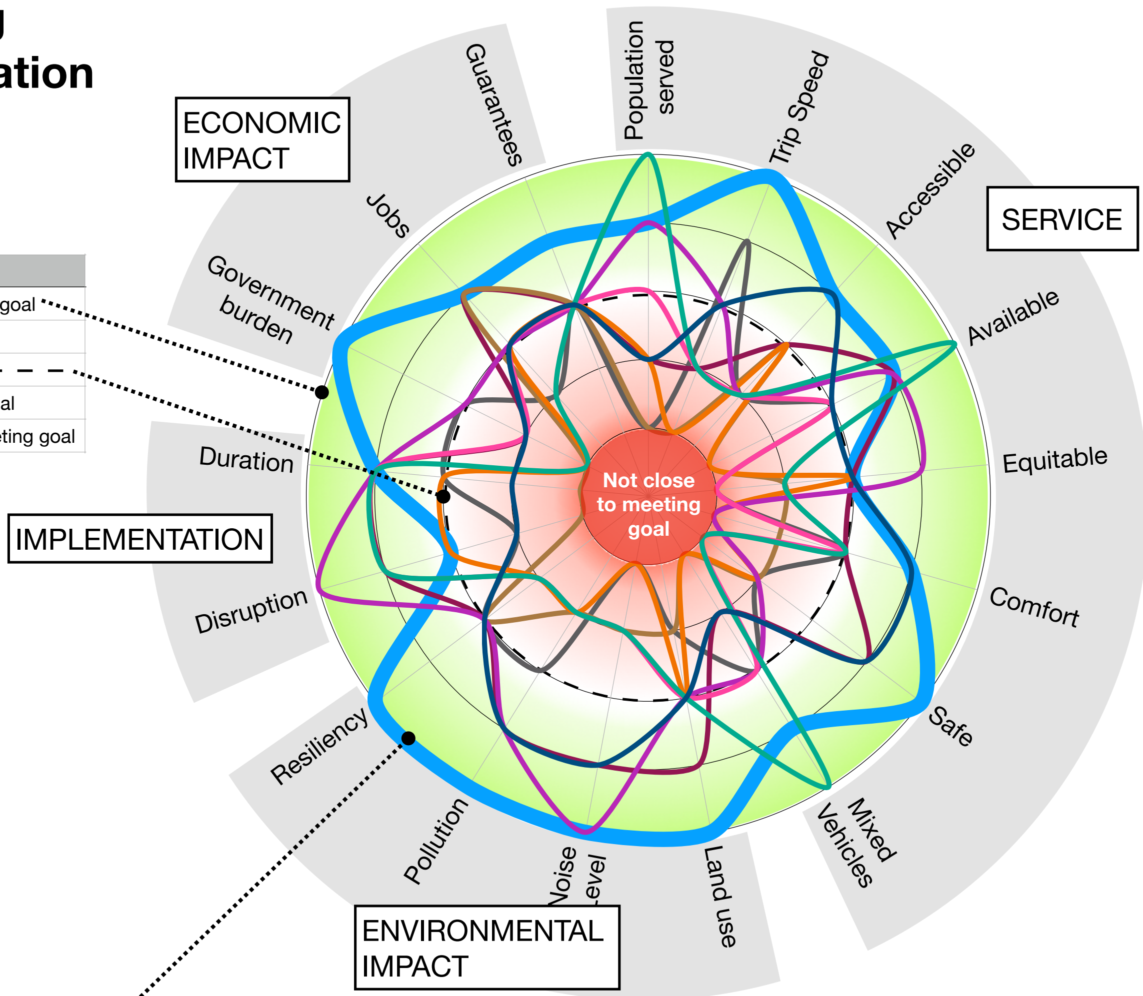
Best-in-class example: Transit X podway

No systems currently operational. Company has commitments for funding and rights-of-way for large-scale projects. Civil infrastructure is mass produced in a factory. Projects are funded from private sources.

Evaluating Transportation Types

Legend

Score	Definition
2	Greatly exceeds goal
1	Exceeds goal
0	Meets goal
-1	Almost meets goal
-2	Not close to meeting goal



Goals ⬇	Podway	PRT	Car (Roadway)	Taxi (Roadway)	Bike (Roadway)	Bus (Roadway)	Rail	Ropeway	Flying
SERVICE	**1.1**	**0.1**	**0.1**	**-0.8**	**-0.1**	**-1.3**	**-1.4**	**-0.1**	**-0.6**
Population served	1	-1	2	0	1	-1	-2	-1	-2
Trip Speed	2	0	-1	-1	0	-2	-2	-1	1
Accessible	1	1	-1	-1	-1	0	0	0	-1
Available	1	0	2	0	1	-2	-2	1	0
Equitable	0	0	-1	-2	1	0	-1	0	-2
Comfort	1	1	0	0	-2	-2	-1	0	0
Safe	2	1	-2	-2	-1	-1	-1	1	-1
Mixed Vehicles	1	-1	2	0	0	-2	-2	-1	0
ENVIRONMENTAL IMPACT	**2.0**	**0.5**	**-0.8**	**-0.8**	**0.8**	**-1.0**	**-0.8**	**0.8**	**-0.8**
Land use	2	0	0	0	0	0	-1	1	-1
Noise Level	2	1	-1	-1	2	-2	-1	1	-2
Pollution	2	1	-1	-1	1	-1	-1	1	0
Resiliency	2	0	-1	-1	0	-1	0	0	0
IMPLEMENTATION	**0.5**	**-1.0**	**1.0**	**1.0**	**1.5**	**0.0**	**-2.0**	**1.0**	**-0.5**
Disruption	0	-1	1	1	2	0	-2	1	-1
Duration	1	-1	1	1	1	0	-2	1	0
ECONOMIC IMPACT	**1.3**	**-0.3**	**-1.0**	**-0.3**	**0.0**	**-0.7**	**-0.3**	**0.0**	**-0.3**
Government burden	2	-1	-2	-1	0	-2	-2	-1	0
Jobs	1	0	-1	0	0	0	1	1	-1
Guarantees	1	0	0	0	0	0	0	0	0
AVERAGE	**1.3**	**0.0**	**-0.2**	**-0.5**	**0.3**	**-0.9**	**-1.1**	**0.2**	**-0.6**
2 Greatly exceeds goal	7	0	3	0	2	0	0	0	0
1 Exceeds goal	8	5	2	2	5	0	1	1	1
0 Meets goal	2	7	3	7	7	7	3	8	8
-1 Almost meets goal	0	5	7	6	2	4	6	5	5
-2 Not close to meeting goal	0	0	2	2	1	6	7	3	3

6. Financials and Acquisition for PRT

Acquisition process open to Innovation

The key implementation drivers for PRT is an acquisition process that is open to innovative solutions. Most acquisition processes are designed to get competitive bids on the same deliverables. This often is an insurmountable barrier for innovative solutions to be considered.

Size Matters

While the Morgantown PRT system has been operating for nearly 50 years, there have been only a handful of small PRT implementations. We contend that the acquisition process itself may be partially responsible for the lack of any large-scale PRT implementations.

Most acquisitions for PRT request a bid for a system of a specific length and number of stations. The proposed routes and stations are like a light rail network rather than a roadway network.

Only a large PRT network will have the network effect necessary to the achieve a high mode share that makes a system viable. If the acquisition process asks for a small network, the risk is much greater.

Perception of risk

A government official will often ask: "Is this system in operation?"

A podway is a type of PRT (Personal Rapid Transit) and ATN (Automated Transit Network) — and hundreds of such systems are operating around the world. Transit X has partnered with Capgemini, a global leader in the engineering and development of automated transit systems.

The Morgantown PRT, another PRT system, has been operating since 1975. The Wuppertal Suspension Railway has been operating since 1901. There are about 37 suspended roller coasters in operation.

A pilot podway was installed in 2021 near Boston and is used for testing and demonstrations. Every podway project starts with a pilot followed by a phased rollout. Over a dozen governments are moving forward with podway projects that are expected to start operations in 2024.

Bias against New

Most acquisitions for PRT require that the proposed system must be currently in operation. Because there are only a few small PRT systems in operation, the only qualified bids are those in which the PRT has shown a limited ability to scale. There are many ways to mitigate risks in implementing PRT, but requiring that the PRT vendor has a system in operation may actually increase the risk of building a non-viable PRT system. Recognize that outside consultants will have a bias towards recommending familiar solutions and a bias against solutions to which they are unfamiliar.

The Morgantown PRT was the first PRT system in the U.S. and it featured an entirely new design. It has been in operation since 1976. Many large-scale infrastructure projects (skyscrapers, dams, tunnels, roller coasters, bridges, nuclear power plants, etc.) all feature a unique design and the vast majority have safely operated for many decades.

One way to reduce risk to the government is for the system to be funded from private sources and without a financial burden to government. In this case, the private funding sources are accepting most risk and the government needs to trust the risk mitigation strategies of the investors and lenders. If the government is not "on the hook", then the government should let the parties with the most at risk, determine how to best mitigate risk.

Bias for Familiar

There is a natural bias towards familiar types of transportation, and that often leads to underestimating the risks and costs of those modes. While cars on roadways are dangerous, polluting, susceptible to flooding, and waste time, these risks are mostly ignored or deemed "acceptable" because they are familiar.

Large public infrastructure projects in U.S. are often significantly over budget and over time — even when using familiar technologies (BRT, Light rail, etc). Japanese high-speed rail has been operating for over 50 years, but the California High Speed Rail project is already 10 times over its original budget and is expected to take 3 times longer than originally estimated. Just because a technology is familiar or common, does not make it necessarily less risky than an unfamiliar approach.

A project that depends upon availability of public funds and subsidies may be higher risk than one that is privately funded. A publicly funded project with a long implementation timeframe is at risk from new leadership at each election, waning public support, and economic boom-bust cycles. An infrastructure project that requires dozens (or hundreds) of land taking actions are more risky than a project with only one right-of-way owner. Transportation projects that cut through communities and pollute may face significant risks from lengthly environmental reviews and legal challenges.

If decision makers do not factor in the real risks of common approaches, it makes innovative approaches appear to have higher risk.

Bias against Proprietary

Unlike railways, there is no "standard gauge" for PRT guideways. It is likely that most components may only be available from a single vendor.

Most large infrastructure projects are unique where the vehicles and control systems are custom built for a particular system, so a proprietary system is not unusual. Many proprietary systems continue to operate for decades. The Wuppertal Suspension Railway is a proprietary system that has been in operation since 1901. The Morgantown PRT system is proprietary and has been operating since 1976. The MBTA in Boston runs on a "standard gauge" track, yet operates six different proprietary train cars types that can not interoperate. Long-term maintenance and supply contracts can assure that if any specific supplier or vendor goes out of business, that the system can continue to be maintained and operated safely.

Most transit systems are unique or proprietary — even when operating on standard gauge tracks.

Goal-based Acquisition

To be open to innovative solutions, we recommend using goal-based targets for evaluating submissions rather than "must have" and "may have" requirements. Goals should based on "what" and not "how". This is like the target goals used in response to section 3 above that could be used to evaluate and compare transportation options across all modes.

For example, rather than specifying maximum capacity, set a target goal for average trip speed for the vast majority of trips. Rather than specify the specific route and number of stations, set a target goal for percent of population that is conveniently served and ask to see the analysis showing how the vendor expects to achieve that target.

Open to needs of private capital

The government acquisition team should be willing to work with selected vendors to make the final agreement attractive to investment by private capital. For example, providing a long-term, binding agreement (concession) for use of rights-of-way. Another example is how to balance the need for fares that are equitable and produce returns that will attract investors.

