Transit X™

Handbook

A companion guide to proposals for a
a privately-funded fleet of fully-autonomous electric vehicles that is

High capacity • High speed • Nonstop • 24/7
Solar powered • Wait-free • Door-to-door • Resilient

transitx.com/transitxhandbook.pdf

2017-12-31

Contents

Word-cloud for Transit X

Transit X™ is a privately-financed transit network with the capacity, convenience, and cost to rapidly supplant cars, buses, trains and trucks — without dependance upon public funding or subsidies.

Background

Who is this document for?

This handbook is for people who want to improve transportation in their city or region. You may be a real estate developer, planner, sustainability advocate, community leader, or works for the chamber of commerce, or in economic development.

This handbook provides details about Transit X and answers many questions. We hope it can equip you with the tools to evaluate and begin a Transit X project in your region.

Transportation Goals

Everyone wants transportation that is convenient, safe, affordable, dependable, sustainable, fast, private, comfortable, and accessible.

Also, we all want LESS of: congestion, carbon/GHG (Greenhouse Gas) emissions, pollution, injuries/deaths, and taxes. We want MORE of: economic development, resiliency, access to jobs, and green space.

The problems with our existing transportation systems are well known. Cars, buses and trucks put a significant toll on the environment and society. Conventional mass transit and high-speed rail are too expensive, and buses are inconvenient. Bicycles only serve a small segment of the population. Electric vehicles offer merely incremental benefits, and autonomous vehicles may increase congestion.

Transit X provides a transportation service that meets these universal goals at low-cost, often at lower cost that repairing the existing railways and roadways. Transit X's economics will make it possible to rapidly transform the transportation system to be car-free and carbon-free.

Overview: Transit X

Transit X is a suspended, ultra-narrow gauge rail network with ultralight pod vehicles. Transit X is a 100% automated network that is high capacity and provides non-stop, single-seat travel from origin to destination on an exclusive right-of-way. It is powered from 100% sustainable energy.

The pods, each carrying between one and five people, quietly cruise above traffic suspended from a track. Destinations are specified — prior to boarding — through a mobile phone or Transit X kiosk. Passengers get into a waiting pod at stops that are as convenient as taxi or bus stops.

Pods quickly accelerate up a ramp to merge onto the track, and then travel non-stop at 73 km/h (45 mph) until reaching the exit ramp at the destination stop. It is a fully automated transportation network with high-capacity interchanges that provide fast, congestion-free travel. Transit X has a minimal footprint on roads or sidewalks — often less area than street lights and bus shelters.

The first systems will be operational in 2018. A full-size test system will be demonstrated in 2017.

In short, we aim to rapidly transform the world's transportation system into one that is both economically and ecologically sustainable. Our goal is to enable cities and suburbs to be both car-free and carbon-free.

Transit X can provide both the financing and full operations for its systems. Its low-cost makes it possible to be profitable and therefore privately-financed.

Technical Overview

Each pod has a 20 pound battery that powers dual electric motors with small 15 cm (6 inch) wheels that run along ultra-narrow gauge 30 cm (12 inch) steel rails. The pod's cabin travels below the rails. The rails are mounted inside fiber-composite beams supported by fiber-composite poles located 23 m (75 ft) apart. Technically, Transit X is a fleet of autonomous electric vehicles that run on ultra-narrow gauge rails, not roads.

Transit X uses proven materials, technologies, components, and processes from other industries. We have avoided higher risk technologies such as magnetic levitation, evacuated tubes, or ultra-high speed operation.

The control system is more comparable to an elevator's control system than to an autonomous road vehicle because the entire system is fully automated and operates on exclusive rights-of-way. The software control system runs on commercially available hardware running a real-time operating system. The control system is distributed, fault-tolerant and fail-safe.

The pod's cabin is a carbon-fiber monocoque shell. There are three major pod types: a roll-on pod, car pod, and cargo-pod. The roll-on pod has a door height of 1.4 m (56 inch), a flat bottom, and a jump seat in the rear. It can hold a stroller, wheelchair, bicycle, or gurney, along with one adult or two children. The car pod has superior aerodynamics and features two bench seats (front and back) that hold 4 large adults or up to 8 children — a a maximum passenger load of 363 kg (800 lbs). The empty pod weighs 45 kg (100 lbs) and can achieve better than 0.23 liters per 100 km (1000 MPGe). A cargo pod carries freight and holds a standard 1.22m x 1m (48"x40") pallet with a max payload of 907 kg (2000 lbs).

The network is all-electric and is 100% powered with sustainable energy. Solar panels affixed to the track generate energy which is then stored in large batteries housed inside the support poles. Pods park where energy is available and charge while parked. A fully-

charged pod can continuously operate over a peak period (2 hours). If there is insufficient solar energy available, Transit X will use other sources of sustainable energy.

ADA Compliance and Handicap Accessibility

Transit X offers the same high service level for people of all abilities. At each stop, unobtrusive vertical lifts provide easy access to the platform. Roll-on pods provide for travel for people in a wheelchair along with a rear seat for an additional person. The blind are accommodated through personal audible messaging and other non-visual reference points.

Luggage

Pods have space for luggage, or passengers may travel in one pod and their luggage in another pod. Both pods arrive simultaneously at the destination. A roll-on pod can carry a full-size bike, skis, stretcher, or surfboard, and offers a fold-down seat for passengers.

Door-to-door

Transit X provides door-to-door travel to the final destination (also known as last mile) in suburbs with local branches — without roads and cars. Pods go 48 km/h (30 mph) along a single track which is smaller and at a lower height than main lines. Stops off local branches cost less than a one-car parking garage and can be as close as 60m (200 ft) apart. The typical walking distance for a trip will be similar to that of a personal car.

High Speed

Pods can travel along highways or railways at 241 km/h (150 mph) on a high-speed Transit X track that carries pod trains of up to eight pods. Pods transition from local to high-speed track using automated interchanges.

No transfers needed (single seat)

Transit X provides convenient, single-seat trips that have no transfers and avoids many of the problems inherent to most mass transit systems and multi-modal transportation.

Freight

Transit X cargo pods can carry up to 907 kg (2000 lbs) and fit a standard sized pallet (1219 mm x 1016 mm; 40” x 48”). Fully-automated freight movement improves efficiency, enables a new level of just-in-time delivery, and reduces the need for trucks on city streets. The scheduled arrival for a pod could be guaranteed within one second, eliminating or reducing the need for loading docks and storage areas.

Final freight recipient

Transit X can provide delivery of goods and packages to individuals and businesses.

A cargo pod carries packages to pod stops where an individual package can be picked up securely. Alternatively, local delivery workers could transport packages from a Transit X stop to the doors of residences or businesses.

Proven concept

Transit X is a new design based on a proven system that has been operating for 40 years in the US. In Morgantown, West Virginia, the University of WVA has been operating a personal rapid transit system to reliably and safely move people on campus since 1978. Dozens of other fully-automated transit systems are currently in operation around the world, and members of the Transit X team have played key roles in the success of these transit systems.

The Transit X system is comprised of well-proven subsystems that have been used in other industries for decades: wheels on steel rails, carbon-fiber monocoque shell, and fiber-reinforced support beams. The safety control system has been the product hundreds of person-years of engineering and development.

Advancements in computing power and material science have made it possible to achieve new levels of capacity, size, and efficiency.

About the company

Transit X LLC was started in early 2015 and is based in Boston, Massachusetts, USA. Its CEO, Mike Stanley, is the primary designer of the Transit X system. He started designing and building autonomous robots in the early 1980's when he was 11 years old. His experience has been primarily in software engineering and systems architecture, and he has held senior management and engineering positions at several technology companies in the Boston area. He earned his Bachelor's degrees in engineering and management from MIT.

Eugene Nishinaga heads up the safety and control systems development. Gene has been engineering critical safety-certified control systems for 40 years, including the Bay Area Rapid Transit system (BART) and Morgantown's PRT. Gene is the author of over a dozen patents and patents pending for high-capacity, fully-automated, transit control systems.

Proposal Handbook

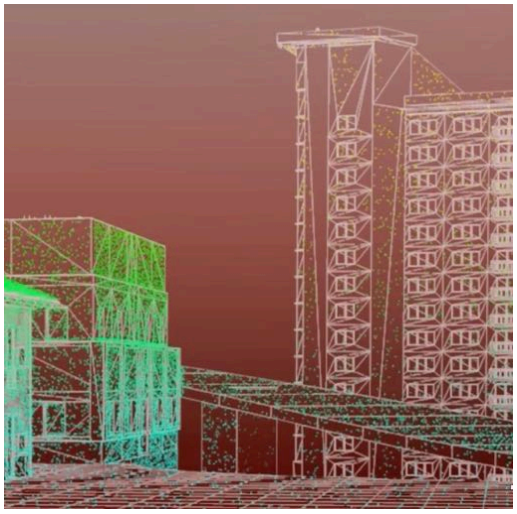
Projects often start with a single person. If you are reading this, you are likely interested in ways to improve transportation, and see Transit X as a potential solution. We hope this handbook can help answer many questions and encourage you to start a proposal for a Transit X system.

Although every place is unique, there are also many similarities and common patterns. This handbook aims to strike a balance between clarity, conciseness, and completeness.

Planning

Cities have been shaped around mass transit infrastructure. Long-range studies and planning are required because the infrastructure is extremely costly and permanent. The concept of Transit Oriented Development (TOD) has been popular because it is much easier to add a building than add a mass transit line. The low-cost and flexibility of Transit X changes the way in which cities can grow and evolve.

For example, when transit infrastructure can be easily added and at relatively low cost, it enables transit infrastructure to be easily extended to existing buildings. The implications are significant. The lack of affordable housing is often the result of limited mobility. There is often housing available, but it isn't convenient. Transit X can provide affordable housing by making existing housing more accessible. The real estate mantra of "location, location, location," is actually more about access and convenient mobility, than location per se.



Point-cloud Survey and 3-D Model

So, does Transit X require planning? Yes, but significantly less than conventional mass transit, and more like planning a bus route.

Transit X networks can scale from a short line to a large, complex network. An initial network can be sketched out in a few hours, and you don't need to be a transportation planner to create one. Here's a straightforward process that we've used when planning networks.

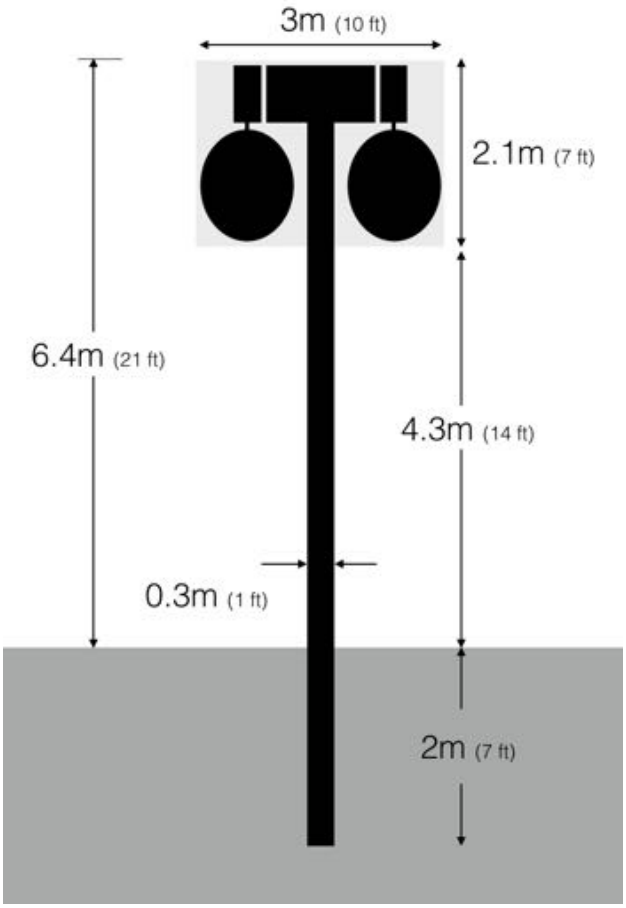
A detailed survey of the as-built environment can be created using a laser-based radar (LIDAR). An immersive 3-D experience of the proposed project may be created.

Identify demand

First, identify the places where people live, work, and play. This can be done with on-line maps, heat maps of Walk Score (www.walkscore.com), or existing transportation studies. When looking at a satellite map, you can use the color and texture on the map to locate service areas. The location of buildings, parking lots, and transportation routes are all helpful to mark. Google Maps highlights commercial areas with a pale yellow background.

At first, you may start with a limited number of routes with a few stops to serve a critical need.

Most light-rail is extremely costly at over $93M/km ($150M per mile), and therefore the goal for planning light-rail is to minimize the amount of track required, as well as minimize any grade (road) crossings. Often, this means many light-rail systems may run along a corridor with little business activity until it reaches a station (trolleys are the



Minimum space required for dual-track

exception). At $3.1M/km ($5M per mile), Transit X is more than 40 times less costly than light-rail, and similar to buses in cost. Transit X runs on exclusive rights-of-way (RoW) that don't interfere with surface traffic — vehicles or pedestrians. Transit X should run along business corridors where there is existing pedestrian traffic and high need for transportation.

Station location

Stations are one of the most costly elements of conventional mass transit projects, so enormous effort is taken to determine their locations. With Transit X, the "stations" are called "stops" or "platform stops" and they take up less space that a bus shelter on a sidewalk. Transit X stops can be placed as close as 61 m (200 ft) apart. For example, two adjacent hotels could each have their own platform stop at their main entrance. Transit X stops cost 200 times less than typical transit stations and stops can be added later when necessary — even after a system has been put into operation. An individual stop may even be privately financed. When planning, don't worry so much about the stop locations because you can leave that until much later.

Parking

Many train stations have parking lots, but that isn't necessary for Transit X. Parking lots should not be built for Transit X because it is usually less costly to extend the network to be close enough to the destination as to not require a car. Transit X can also connect to existing underutilized parking areas, effectively unifying multiple parking lots.

Vehicles

The number of pods requires even less planning. Pods can be added on a weekly basis as demand requires, and the system can help forecast when more pods should be added to satisfy demand.

Aim for car-free

We recommend that your planning consider making an entire region car-free. Roadways have varying size and capacity: local, collector, arterial, and highway. A rule of thumb is that to become car-free, you'll need a Transit X network to cover collector and arterial roads, and less local roads or highways. 90% of the population should be within a 5 minute walk of a line, and the majority of trips should require less than 10 minutes of walking.

Pilot

A pilot project is recommended, and we recommend identifying a number of potential pilot projects where one or more of those pilots can be constructed in parallel as the networks expand and connect. Some roads will be easier to use than others due to road width, rights-of-way, buildings, trees, street parking, utility lines, signage, signals, light poles, and other constraints at the surface and above ground. Identifying several potential locations is recommended so that multiple options can be considered.

These planning guidelines are simplifications, but certified Transit X professionals can help guide you through a short and productive planning process.

Rights-of-way

Acquiring the necessary rights-of-way (RoW) may be one of the most challenging parts of the project. On one hand, it should be relatively easy because Transit X does not require land, uses only a small elevated RoW, has minimal negative impact, and provides many positive benefits. That said, any change to the public rights-of-way is often difficult and contentious. It requires support from the community, civic leadership, and a number of stake holders.

Land Use

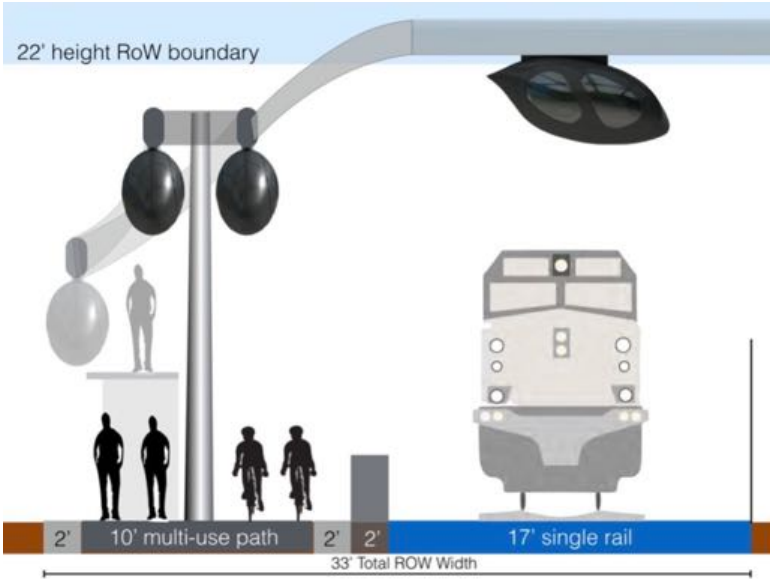
Let's start by defining the physical RoW size and location. The required space for the dual-track is a space 3 m (10 ft) wide, 2.1 m (7 ft) tall, and located at least 4.3 m (14 ft) above the road surface. The bottom of the track is 5.8 m (19 ft) above the road surface, 30 cm (1 ft) wide and 61 cm (2 ft) tall. Although maintenance or repair facilities should ideally be located somewhere on the network, that is not a requirement. See the "Garage" section for the dimensions for a pod garage. As a general guideline, a single pod replaces over 30 automobiles due to higher utilization, faster trips and shared vehicles.

Poles

30 cm (12 inch) diameter poles are located approximately every 23 m (75 ft) and directly embedded 1.8 to 2.4 meters (6 to 8 ft) into the ground, with appropriate precautions to avoid underground utilities. Street lighting, signs, traffic lights, and bicycle parking may be attached to the poles.

Utility Relocation

Power and utility lines may need to be relocated. Transit X tracks contain multiple conduits inside the beams to run power or telecommunication cables. Pole extensions may also be used to attach wires above the tracks. We would work with local utilities on an approach for relocating wires either around, inside, or above the Transit X tracks.



Rights-of-way near railway or community path

Trees

For streets with trees, there are three main options: 1. avoid, 2. trim, or 3. move. For streets with utility lines, you can either avoid them or “bury” them by relocating utility lines to ducts inside the track.

Stops

Each platform-stop requires at least one flight of stairs that occupies a rectangular footprint that is 0.9 m (3 ft) wide and 1.5 m (5 ft) long, but the space under the stairs can be commonly used for trash and recycling bins, mailboxes, and parking for bicycles.

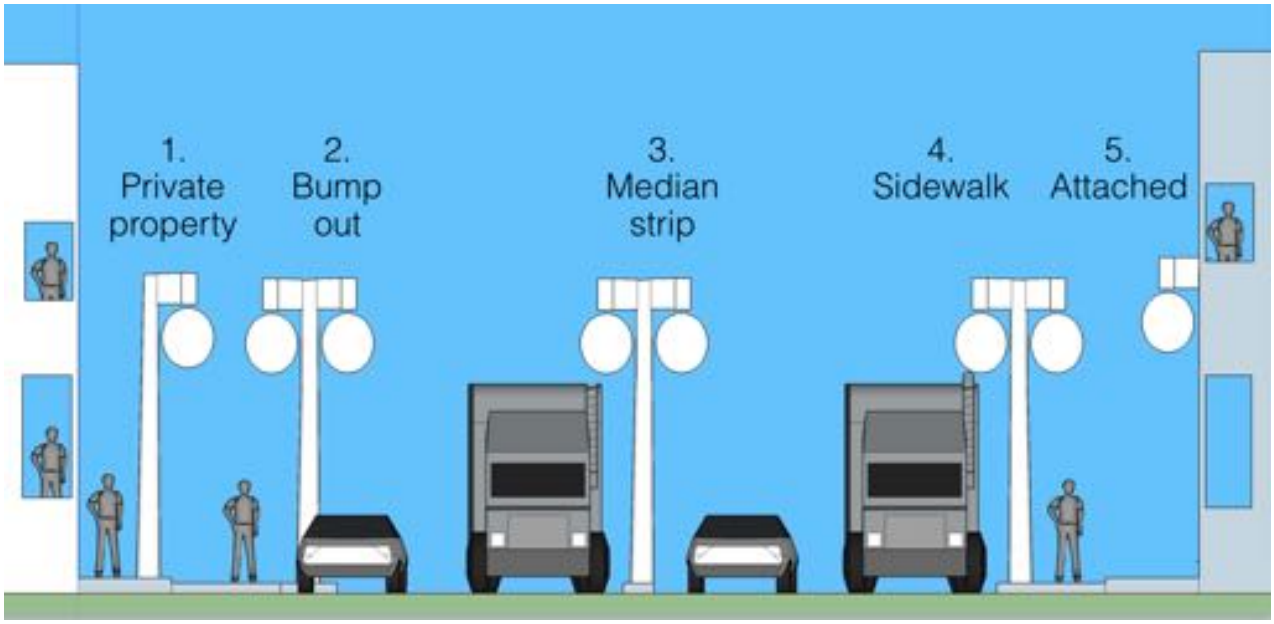
Legal

The legal RoW will often take the form of a real estate easement. Many local municipalities simplify RoW access for utility

providers (typically telecoms and power companies) through use of an ordinance. In exchange for the use of a RoW, the RoW owner might receive a percentage of revenue (or profit) for the value of traffic going over that RoW.

Historically, eminent domain has been used to facilitate the building of surface transportation networks such as rail and roads, but the power of eminent domain is often highly charged and evokes fears of the government taking private property. Politicians and civic leaders will generally avoid using the power of eminent domain unless the project is strongly supported by the community, so it is important to earn the support of the community and its leaders.

The benefits to be gained will likely far outweigh the costs, as a community can become more walkable. Transit X can embed and hide unsightly utility lines and poles, and offer municipalities the ability to run telecom lines, high-efficiency street lighting, high-speed wireless data, and electric vehicle charging ports.



Multiple options for track location

RoW Ownership

Rights-of-way (RoW) for Transit X can be located on many types of property: private property, railways, roadways, or highways. The local municipal planning office can help identify RoW owners.

Private RoW

Locating Transit X within a single private campus will usually have the clearest path to a RoW. Some examples would be a large shopping mall or casino resort. Office parks will often have public roads.

Railway RoW

Long-haul railways are usually owned by one of a handful of major freight railroads. For urban rail transit, railways may be managed by the state's DOT or jointly owned through complex agreements. Short-haul routes are often privately owned and managed, or may have been transferred to local municipalities for rail trails or roads.

Railways and highways are preferred for long-distance routes because they have relatively straight runs.

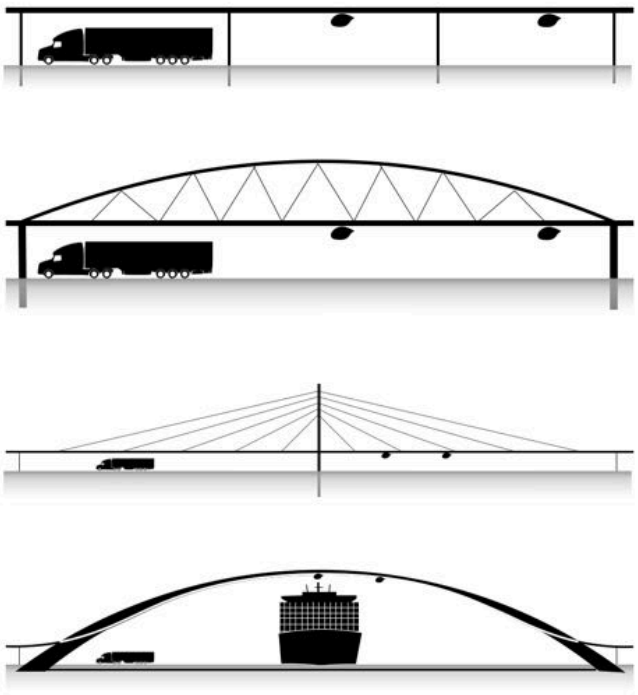
The RoW should be located as to not impact railway operations. Due to the clearance height required for trains, the pods may need to clear 7.6 m (25 ft) when crossing a railway.

Road RoW

Along roads, the poles may be located near the curb along a sidewalk, on a bump out, or along the middle of the road along a median strip. It is also possible to attach them directly to the side of buildings.

Roads may be owned by the local municipality, county, or state.

Transit X fits under existing highway overpasses



Types of bridges

Highway RoW

A track can be located along the center strip on a highway, or outside the shoulder. It is usually prohibitively expensive to modify any overpasses or other crossings, but most tracks can be located in the sloped area outside the bridge pillars. If that space is not available, the tracks can go below ground or up and over the overpass.

Multiple RoW Owners

Some areas will have multiple RoW owners that can complicate getting a RoW easement.

For example, a short stretch of railway in Cambridge, MA along the MIT campus involves at least 5 entities: the railroad, MIT, City of Cambridge, MassDOT/MBTA, and private property owners. There are agreements on the use of the rights-of-way, along with air-rights above 6.7 m (22 ft), surface level, and below the ground.

Due to these potential issues, we recommend investigating multiple RoW options in parallel and getting an early commitment from RoW holders.

Challenging terrain

Bridges

The elevated track is a continuous bridge with 23 m (75 ft) spans, but when crossing water, large intersections, or gorges, longer spans and higher clearances may be required. There are three different types of bridges depending upon the required length. These basic bridge designs can cross long spans with high clearances.

Steep slopes

A standard track can climb a maximum of 27% grade slope (15 degrees), but other track configurations can traverse slopes of any grade.

Earthquake prone areas

Transit X is earthquake resistant, but earthquake prone regions may require special considerations.

No roads or sidewalks

Some extremely dense urban environments may lack the space for roads or even sidewalks. Transit X is designed to service these challenging areas.

Demand

Demand is the number and type of trips that are expected. Demand can be described by the number of daily trips, distance per vehicle per day, mode share, and specific demand for origin-destination pairs. Peak demand is calculated for both a track and at a stop. A system's capacity is designed to handle the demand at some level of service.

Estimating the amount and type of demand is important for both sizing the network as well as estimating the revenue to pay back loans. A proposal has an economic model that estimates demand, cost, and revenue based on inputs such as mode share.

Estimating demand can be complicated, difficult and error prone, and providing the wrong level of capacity can be detrimental to a project's success. Transit X dramatically simplifies the work for estimating demand and providing capacity.

A single Transit X track provides the equivalent capacity of 12 highway lanes. In most cases, this capacity is enough to support most demand, and where more is needed, more tracks can be added. Capacity planning for other systems is much more difficult because of the exorbitant cost, limited capacity, and the difficulty in adding (or removing) capacity over time.

Adding additional Transit X pods to meet demand is easy. Unlike most rail systems where adding new railcars and changing schedules can take years, adding additional Transit X pods takes days. Transit X is on-demand and no-waiting, so there are no schedules that need to be updated.

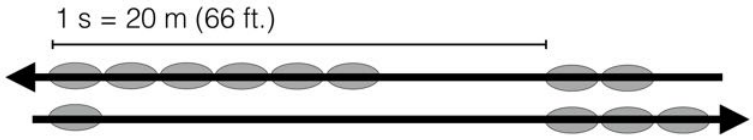
Accurately estimating demand is difficult to do and estimates are often wrong. Improvements to the system might significantly change people's behavior. For example, if a typical commute is reduced from 60 minutes to 30 minutes during peak hours, demand will increase during those hours.

Transit X's approach is to provide extremely high-levels of base capacity, along with the ability to easily scale as necessary. No other transportation system gives you this level of capacity, cost, and flexibility.

Capacity

Transit X is a high-capacity network that scales to serve high density cities, low-density suburbs, and inter-city travel. Capacity is defined as how many people the system can move in a given period of time, often specified in maximum passengers per hour per direction (pphpd, or pph for short), and defined for five categories: track, stop, interchange, parking, and surge capacity.

Track Capacity



Line capacity of each track is 21,600 pph

Line capacity is the number of people that pass through some point. For Transit X, maximum capacity for a single track is 21,600 pph — the equivalent of 12 highway lanes. This assumes shared pods with an average of 2 passengers per vehicle.

Three factors enable such high capacity:

1. Automated pods only require a 1 second gap where cars average 2 seconds
2. Pods can be shared to double the average vehicle capacity
3. Pod trains (multiple pods traveling together) triple the capacity assuming an average of 3 pods per train

If there was a critical need, such as during an evacuation, pods could be filled to capacity which could achieve 43,200 pph.

Load Capacity

Load capacity is the number of people that can board (or exit) at a station or stop. For Transit X, a single bay on a platform stop can load/unload a pod with two people every 6 seconds on average, for a load capacity of 1,200 people per hour, or the equivalent of a continuous stream of buses.

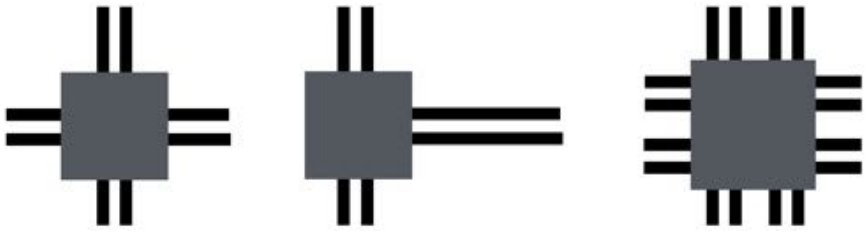
Loading capacity at a Transit X stop is scalable. Stops are small and can be placed as close as 61 m (200 ft) apart. Additionally, stops can be easily added at a later date.

Each stop can accommodate up to 5 parallel loading platforms, which increases capacity to 6,000 pph. A platform can be added overnight.

Additionally, each loading platform can be lengthened to accommodate up to 5 serial loading areas, providing triple the capacity for one loading platform.

Interchange Capacity

Umbrella™ is a Transit X interchange. It fits above an existing urban intersection and provides higher capacity than a large highway interchange. An interchange is scalable and can be easily upgraded to meet any demand. Each interchange supports turning in any direction (including U-turns) and each interchange provides a base capacity of 1,800



Transit X Umbrella is a high capacity and scalable interchange

"turns" per hour or 8% of track capacity. Optional dedicated "turning lanes" can be added to meet demand of up to 100% of line capacity.

Parking Capacity

A Transit X pod garage provides a high-density, flexible parking structure for pods that can be either enclosed or open.

A small pod garage is usually located at a platform stop and provides anywhere from 2 to 20 parking spaces. It requires a 1.2 (4 ft) width, a 1.8 m (6 ft) height, and a 2.1 m (7 ft) length per pod.

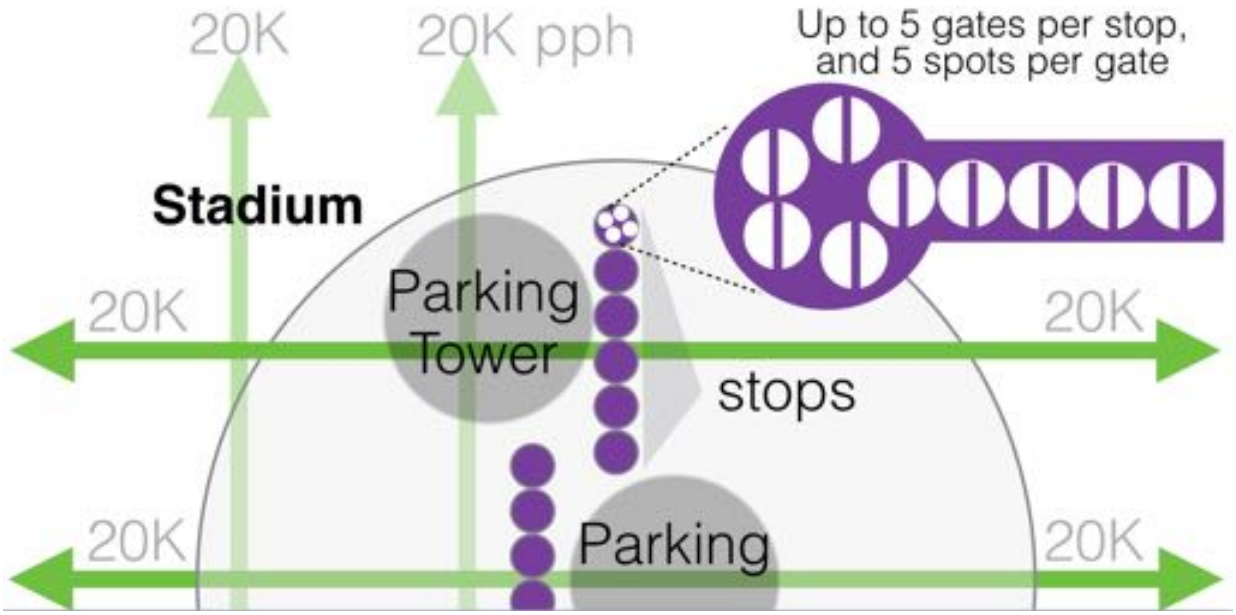
A pod garage can be configured for any height, width, and length. Garages are typically located at likely surge points and directly feed loading areas. They do not occupy any footprint on the ground other than support posts.

Surge capacity

Large stadiums hold over 100,000 people and when an event ends everyone wants to leave simultaneously. Handling this surge of demand is one of the most challenging situations in transportation because there is such a high demand over a short period of time.

Although the standard configuration should provide enough capacity for most situations, Transit X can scale to handle any flow of people — even in excess of 2,000 people per minute or the equivalent of 100 buses loading simultaneously. To achieve such extreme capacity, multiple stops can be placed as close as 61 m (200 ft) apart, boarding can occur at grade, multiple pods can be loaded at a single gate, and dual tracks can be temporarily reconfigured to provide 100% outbound travel from a central point, and high capacity parking structures provide pods at a high rate into stops without using the main track. For stadiums, tracks encircle the stadium to allow boarding at all stadium exits.

The cost for providing such surge capacity using traditional transportation modes is often prohibitively expensive, whereas Transit X can provide the capacity for less cost than parking lots — and with a minimal footprint.



Transit X stations can scale from 1,200 pph up to 2,000 passengers per minute

Revenue

Most transit systems operate at a loss, but Transit X operates at a profit.

Revenue comes from fares, where a fare is based on the trip distance — similar to a taxi service. Transit X enables differentiated levels of service with variable fares, similar to airline seats. This enables both highly discounted fares as well as high-margin fares.

In addition to passenger fares, revenue from Transit X can come from many other sources: freight, in-pod entertainment and advertising, business fees, private shuttle contracts, utility line leases, carbon offset credits, school bus contracts, and naming rights. There will be no exterior advertising on tracks or pods.

Risk mitigation

Transit X works to remove the risks associated with mass transit systems. When it comes to transportation, we understand that everyone wants someone else to be first.

A test system will be demonstrated in 2017, and the first network is planned to start operations in late 2018 or 2019 in the Boston area. Every project can assume that Transit X will be operating elsewhere before starting installation. The total project cost also includes the cost of removing the system, further minimizing project risk.

Factory manufacturing of the components insures a consistent repeatable process that provides for a low-risk and fast installation — similar to the installation of utility poles and power lines.

It is important to realize that there are significant risks by continuing with the status quo. Some seeming low risk paths, in practice, are higher risk than Transit X. For example, the existing roadways and railways incur the risks from:

- Damage & shutdowns from storms/floods
- Catastrophic failure from old infrastructure
- Loss of life and limb from crashes
- Depressed growth from low productivity
- Health risks due to poor air quality
- Cost overruns on big infrastructure projects
- Rising bond rates for financing expansion
- Disruptions from construction
- Increased GHG emissions from transportation

An analysis can show that the risk of deploying a Transit X network is lower than the risk of continuing with the status quo of transportation.

Aesthetics

Transit X has been designed to be compact, clean and quiet — and much less intrusive than the existing road system.

Past elevated transit systems have been blights that have a significant negative impact on neighborhoods — imposing monstrosities that block views, create dark spaces, and spew fumes and loud noises. It's no wonder that many elevated systems have been taken down. Transit X is orders of magnitude smaller, quieter, and cleaner and therefore the objections to conventional elevated transit do not apply.

Transit X should be compared to the existing roadways when answering the question: "Does Transit X improve the quality of life in a community?"

Transit X in Boston (rendering)

Conventional elevated transit

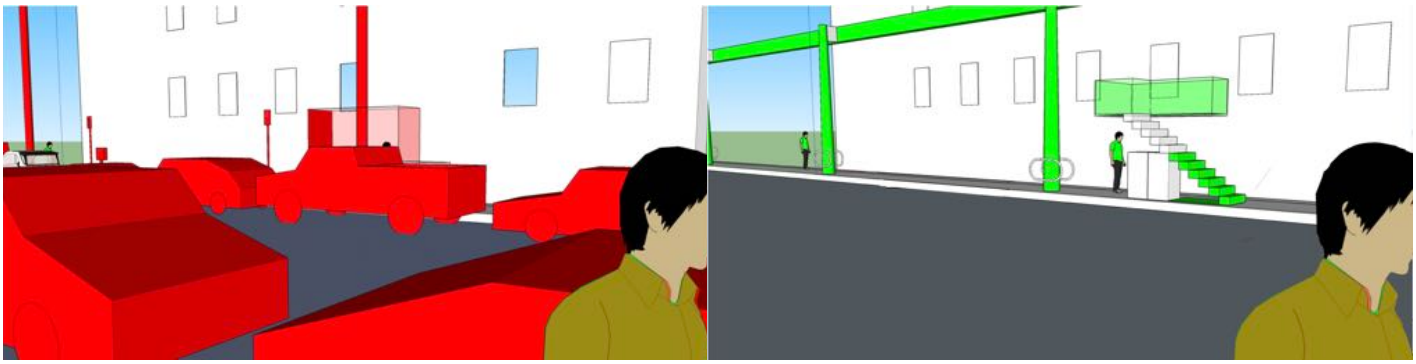
Our cities and suburbs are now designed for cars and trucks. Many things that now reduce the quality of life are just considered "normal" and unavoidable. For example: asphalt roads, parked vehicles, parking lots, traffic lights, street lights, signs, and sirens. Nearly half of the land area in a city is dedicated to transportation. Most of the obnoxious noises, grime, and pollution also come from road vehicles including brake dust, rubber bits from tires, and dripping fluids. Roads are significant contributors to heat island effects and cause runoff that pollutes our waterways.

To answer the question "Does Transit X improve the quality of life in a community?", let's look at some positive impacts Transit X would have: Improved safety for pedestrians and bicyclists. Fewer cars and trucks, fewer parked cars., dramatically less noise, less travel underground, no exhaust, smells, dirt, or grime, more green space, more space for bicycle lanes, less light pollution, and less road repair and construction.

The motion itself isn't a blight; it's the fumes, noise, and vibrations that people hate. Transit X dramatically improves the quality of life in a neighborhood.

Aversion to Elevated Transit

We experience a city when we are outdoors walking around. Ground level is where we walk, bike, eat, play, and talk. The lifeblood of retail is at ground level. By having featherweight pods cruise above traffic, you reclaim space where it is most valuable — on the ground. Transit X has such low impact that even people on the second floor will



Transit X removes much of the street and sidewalk clutter. Red (on left) replaced by Transit X in green.

Underground and green screens options

Example of modern form in harmony with historical areas

Cross section showing roadway vs. Transit X (green)

experience a much higher quality of life compared to the existing road system.

Elevated systems were taken down, because they lowered the quality of life — the noise and vibrations from the trains were intolerable. The structures blocked views and natural light and traveling underneath those structures was a dark and unpleasant experience. There is a stark difference between that and Transit X. Transit X is quiet and has a minimal impact on views or sunlight.

Architectural fit in historical areas

There are many excellent examples of marrying modern technology with distinguished architecture. I. M. Pei's glass pyramid in the Louvre's courtyard in Paris is one such example.

Historical cities would dramatically benefit from a more walkable and car-free city. Removing parked cars and reducing black asphalt would dramatically enhance visual beauty.

The poles, tracks, and stops can have a custom style and color to fit the surroundings. Transit X may also be installed underground or hidden by living green screens.

Communities prefer to bury ugly utility lines, but the cost is often prohibitive. Transit X provides a low-cost method for hiding power and other utility lines.

Privacy concerns

Transit X offers greater privacy than current roadways, because the pods travel non-stop at 73 km/h (45 mph) and have obstructed side views, eliminating the potential for gawking. The viewing height from a pod is only 2.5 m (8 ft) higher than on a bus.

When you compare the sight lines as seen from a second floor window, the visual impact is less than existing cars and trucks on a road.

Stakeholders

A good place to start a project is by identifying key stakeholders and the role they may play.

Champion

This may be you, the reader. A champion knows the region, its challenges, and knows some of the stakeholders. A champion can work with Transit X to develop a proposal and organize stakeholders.

Community

Community support is essential for a Transit X project. There can be any number of community groups: historical commissions, sustainability committees, bicycle advocacy, school groups, etc.

RoW (Rights-of-Way) holders

Transit X requires agreements with RoW holders to operate. This may be a private company, a municipality, a county, or state.

Municipality

Networks running on streets will use RoW controlled by the city or town. Local municipal leadership and staff focused on transportation or economic development are critical to project's success.

State and Federal representatives

Transportation agencies

Metropolitan Planning Organizations (MPO) and Transportation Authorities (TA) may exist, and their role is to improve transportation in an area.

State DOT

The Department of Transportation for the state may be involved if using a state-owned rights-of-way or for inter-city projects.

Commercial real estate developers

Major real estate developers and property owners in the area will have relationships with financing sources and the local government. Commercial developers may greatly benefit from the project and potentially provide the project's equity.

Local business groups

The local Chamber of Commerce and business networking groups can help reach out to local businesses.

Organizational structure

Each project will be part of a Regional Operating Company (RoC) that is typically a Public Private Partnership (P3). A P3 is usually necessary because Transit X operates within the public rights-of-way and therefore needs an agreement with the government entity that manages that public rights-of-way. There are many forms of P3, but a Transit X RoC P3 will be a DBFO (Design, Build, Finance, Operate).

DBFO supports a service model where a Transit X RoC is responsible for all phases: Design, Build, Finance, Operations and Maintenance. The project may qualify for tax-exempt status as a service contract if all Internal Revenue Code requirements are satisfied.

Unlike many regional transit systems, Transit X networks will likely connect over time to form larger networks that span political boundaries. These networks need to synchronize operations to assure a smooth automated handoff of control. A DBFO P3 enables this structure.

Transit X LLC will be a public benefit company where 5% of profits will be donated to local organizations to help improve the quality of life. For example, creating or improving green spaces with landscaping, outdoor community facilities such as parks or public restrooms, bike paths, helping to clean or maintain paths and sidewalks, wider walkways, and improved accessibility.

Procurement

The financing of transit systems almost always go through a public procurement process. Because Transit X provides private financing, and the rights-of-way are non-exclusive, the typical Request for Proposal (RFP) process is probably not necessary.

Costs

Transit X is much less costly than light rail systems and is even lower cost than many roads. Its life cycle costs are comparable to a shuttle bus or bus rapid transit (BRT), but with much higher capacity and convenience. In general, Transit X costs less than maintaining the existing roads and railways.

Costs falls into one-time capital/project expenses and ongoing operational expenses.

Capital costs

The capital costs for Transit X are approximately $3.1 per km ($5M per mile), including physical infrastructure (pods, track, stations, interchanges, maintenance facilities, and operations centers), as well as soft costs (planning, permitting, and environmental impact assessments). Transit X's capital costs are low due to: less material, and lower construction and land costs.

Optional infrastructure includes street lighting, burying utility lines, EV charging stations, and bicycle racks.

The pods and track consist of standard, modular components that are factory-built and can be quickly assembled on-site. This translates into significantly lower labor costs, and faster, more predictable installation. Transit X's infrastructure contains 1/100th the material than railways or roadways of the same length.

The track has no moving parts, and does not carry power to the pods. Each pod has only a handful of parts: fewer parts leads to lower costs for both manufacturing and maintenance.

Soft costs are low because Transit X is environmentally sustainable, and can easily scale to adapt to changing needs. The cost of removal is built into every proposal as a method to control soft costs. For example, there is less need to do costly long-term planning when the network can be easily expanded, moved, or removed.

Operational costs

Transit X is anticipated to have operational costs of just a few cents per passenger-kilometer — much lower than other modes of transportation. Labor and fuel make up the majority of operational expenses for most rail or bus systems. As Transit X is fully automated there are no driver salaries. While there is no fuel cost, the energy cost for sustainable power may be included in either operational or capital costs. In addition, the pods have only a handful of easily replaceable parts, and the poles and track are made of corrosion-proof materials more durable than concrete and steel. A sensor-laden network provides continuous monitoring and detection of potential issues.

Financial model

A separate spreadsheet helps calculate an internal rate of return for a proposed system given a few primary inputs such as area, population, mode share, and network length. A table of assumptions provides default values for fares, interest rates, length of loan, etc.

Financing

Capital costs are financed as long-term debt through either commercial loans, private equity, government programs, local funding, or private bonds. Transit X is working with investment banks and private equity firms to secure project financing.

Commercial Loans

Small networks could be funded through commercial real estate loans, as Transit X is a type of commercial real estate.

The equity component of the loan would come from real estate developers or large employers. Those organizations would directly benefit from improved transportation as well as receiving an income stream from the profits.

A commercial loan will generally have a higher interest rate than private bonds, but lower transaction costs. It is also more flexible than private bonds because the terms of the loan may be restructured.

Private Equity

Private equity may also finance projects, as they do toll roads or airports. Some private equity firms specialize in funding green infrastructure or projects with positive social impact.

Government programs

Governments have programs to fund or support infrastructure and clean energy projects. They span many different levels, and this is only a partial list and programs that may apply (in the US):

FTA, FHWA, FRA, DOE, Investment tax credits for battery storage and solar, Transportation Enhancements Program, FAST ACT, TIGER, FASTLANE, New Starts, Small Starts, Urban Partnership Agreement/Congestion Reduction Demonstration.

World Bank

Some regions would be eligible for project funding from the World Bank or similar international organizations.

Local funding

A Transit X network might use municipal funding options through Tax Increment Financing (TIF), Transportation Utility Fee (TUF), or value capture.

It might also be possible for a community to use crowd-funding.

Private green bonds

For larger systems, private bonds for sustainable infrastructure projects may be used. The Transit X RoC would offer the bond and the equity component would come from real estate developers or government programs.

Passenger Interface

Passengers of all abilities will be able to conveniently use Transit X.

Multiple touch screens will be mounted on the pole closest to a platform-stop. These ground-level kiosks, along with a mobile phone app, allow passengers to select their destination, authenticate, and provide payment. A screen on either side of the gate opening will provide destination confirmation and system messaging. Each pod will have a touch screen accessible from both the front seat and back seat. These screens will display public service announcements, system messages, advertising, and entertainment.

Authentication

Identification of each passenger will be performed by one or a combination of: a smart card, smart phone, BlueTooth ID, hand print, and facial detection. The information of who is riding in a pod remains anonymous, unless demanded under local laws.

Payment

Transit X payments are cashless and use a tap-to-pay card or smart phone app. Transit X will integrate with each region's major payment systems.

Selecting a destination

Each platform stop will have both a name and a number. The destination is entered through a kiosk or smart phone app by touching a location on a map, entering a street address, stop name, or stop number. For most people's daily commute, the traveler's default destination will be assumed based on their history.

Through an app, special requests can be made for multiple pods at specific stops at specific times.

Transit X is designed to be used by everyone, including small children as well as people with all types of physical and mental disabilities.

Installation

Most construction projects are extremely disruptive to the community, leading to significant levels of stress on residents and businesses.

Transit X is minimally disruptive to communities as there is little on-site work. All of the components are factory-built and quickly assembled on-site. A team of only 40 workers can install Transit X at the rate of 1.6 km (1 mi.) per week in an urban environment. There is no steel to weld or concrete to pour. The only disruption is the digging of holes for the poles, comparable to the installation of a utility poles and much less disruptive than paving a road or pouring a sidewalk.

Community

Transit X aims to offer communities a superior transportation service that dramatically improves the quality of life. We look to earn the trust and support from the community where Transit X is proposed. We aim to improve safety and health, reduce air and noise pollution, and make a town or city more walkable and peaceful.

Five percent of profits will be used to support work that enhances the quality of life in the community where Transit X operates. For example, improving landscaping and green space, public art, improving or expanded sidewalks and bike lanes, and many other possibilities.

Transit X also gives communities and neighborhoods unprecedented control over their transportation system. Unlike existing roads, a community can automatically enforce limits on speed and use based on the hour of the day. Specific stops could have limits on use based on time of day, and resident status.

The tracks and poles provide a public art space on which a community can feature local artists, enhancing the areas unique character and encouraging pedestrian traffic.

Sustainability

Transit X is a solar-powered, carbon-free, emissions-free transportation network that achieves new levels of efficiency, sustainability, and low environmental impact.

The vast majority of our current transportation system is powered using fossil fuels and is responsible for generating nearly one-third of greenhouse gases. Transit X aims to help rapidly transition to a sustainable form of transportation which leads to significant reductions in green house gases — slowing or perhaps even reversing global warming if widely adopted.

Each pod has a small battery pack that powers two small electric motors. Transit X generates energy from solar panels on the track, stores energy in battery packs contained inside the poles, and recharges pods when they are parked. Optional connections to the electrical grid enables Transit X to buy and sell sustainable energy. There is no 'third rail' providing power while pods are moving.

Transit X will be one of the most efficient modes of transportation due to its low weight, low rolling resistance and sleek aerodynamics. A pod is estimated to achieve better than 0.23 liters per 100 km (1000 MPGe), or approximately ten times more efficient than electric road vehicles.

Transit X uses non-toxic, long-lasting, recyclable materials. Pods weigh only 46 kg (100 lbs) where an average car weighs 1,800 kg (4,000 lbs). Brake dust, oil spills, fumes, and other pollutants are also eliminated with Transit X.

Because of the sustainable design, we believe that environmental impact assessments will go smoothly or perhaps not even be required for most projects.

Resiliency

Transit X is designed to achieve extraordinary resiliency so that it continues to operate in all conditions. One key to high resiliency is that the transit infrastructure is above the ground, and the rails are protected from the elements. Resiliency also improves safety by eliminating possible causes for crashes.

The scenarios that Transit X is designed to withstand is comprehensive: vehicular impact; mudslides; severe winter storms; extreme heat; major earthquakes; solar flares; blackout; severe flooding; GPS failure; trees falls; tornados; power loss or electrical failures; stopped pods; evacuations; parades or street demonstrations; building fires; cloudy days; gun shots; ice storms; cell phone blackouts; hurricanes; road construction; fuel shortages; vandalism; cyber attacks.

All critical systems feature redundancy and fail-safe operation. The proposed system is designed to continue operations in all conditions with an uptime goal of over 99.5% running 24/7. The scheduled downtime for expanding the network is typically less than a few hours. Pods can be automatically rerouted when a track segment or stop is temporarily unavailable, minimizing any inconvenience for the passengers.

Resiliency also means recovering in the event of physical damage. Transit X uses modular, standardized, factory-built components that can be easily installed, maintained, and replaced from stock, typically within 24 hours.

Cyber-physical Security

Transit X is much less susceptible to cyber attacks than autonomous road vehicles. Security vulnerabilities can be patched within an hour without over-the-air updates. Vehicles are continuously monitored and protected against unauthorized access. The primary communication system uses ultra-short range wireless technology, which is immune to jamming or interception.

Safety

Every year in the United States, there are over 32,000 deaths and millions of injuries on roads. In the airline industry, most years feature zero deaths and a few injuries. The safety level of Transit X is more comparable to the airline industry than the car industry.

Transit X would nearly eliminate all unsafe conditions and crashes. Based on well-accepted statistical methods, we estimate that Transit X will be 4 to 5 orders of magnitude safer than roads. It would be one of the safest transit systems in operation, reaching a safety level similar to airline travel.

Fully automated network

Every pod on the network is completely automated. The system does not have the complexity and safety issues that come from automated cars mixing with human-driven vehicles, or switching between automated and non-automated modes in an autonomous vehicle.

Since there are no drivers, there is no possibility of drunk driving, distracted driving, falling asleep at the wheel, impaired driving, or crashes due to driver error.

We are using an innovative transit control system, patent-pending, to manage distances between vehicles to guarantee safe operation with worst-case scenarios.

Redundant and fail-safe

All safety-critical systems, such as position sensing, braking, communications, and propulsion have multiple levels of redundancy and fail-safe operation.

The proposed system uses solid polyurethane wheels and not inflatable pneumatic tires, so the chance of a crash due to a blown tire is eliminated.

Anti-derailment

The system features an anti-derailment design that makes it impossible for pods to come off the tracks. Empty pods weigh only 45 kg, so the absence of heavy vehicles makes the system inherently safer. The pods use small, 8 kg batteries and don’t have a gas tank with the potential to explode.

Automobiles are generally inspected once a year while pods are continuously monitored, so crashes due to a failed component are exceedingly rare.

Authenticated use

Every passenger is authenticated on Transit X and video recording captures people entering and exiting pods. These features have been shown to significantly reduce assaults, theft, and vandalism.

Grade separated

When a system is grade separated, there are no at- grade crossings or intersections. Pods are always operating on a dedicated rights-of-way that physically separates pods from every other mode of transit including pedestrians and bicycles. Grade separated travel increases walkability and pedestrian safety.

Anti-suicide

Rail and road vehicles are used in a significant percentage of suicides because jumping in front of an oncoming train or bus is one of the most effective ways to commit suicide. Transit X is a grade separated, suspended railway where it is not possible to walk on tracks or jump in front of a pod.

No loitering

When there is no waiting, there is no loitering, which reduces the opportunity for assaults or other harm.

Safe sharing

The Transit X pods feature physically separated front and back seating, so that all vehicles can be safely shared with another person. In addition, sharing is optional.

Emergency Egress

If a pod breaks down, it is automatically pushed to the next stop where passengers can exit and the pod is taken out of service. In the highly unlikely event where a pod cannot be pushed to a stop, pod doors may be removed in an emergency so that passengers can exit a pod and step onto the roof of a truck or be lowered on a ladder.

We believe the proposed solution provides a level of safety that is unprecedented. A fully automated, on-demand, grade-separated transit system with a resilient design and a fixed rail delivers a level of safety that no other mobility solution can approach.

Safety Certification

Road vehicles go through extensive safety testing and certification, yet crashes kill over 32,000 people per year. The Morgantown Personal Rapid Transit system is self-certified, and has had zero accidents in forty years of operation. The amusement ride industry is also self-regulated and has demonstrated an excellent safety record. Government safety regulations are not necessarily required to achieve high levels of safety.

In the United States, Transit X would be classified as an Automated People Mover and falls under Federal Transit Administration (FTA) and the ASCE APM (Automated People Mover) standards.

Other transit systems that are also fully automated, grade-separated, and provide redundant critical systems have demonstrated to be more than 10,000 times safer than cars. For example, the Morgantown PRT has had a stellar safety record.

Regulations that would require common-sense safety devices such as airbags, seat belts, bumpers, crumple zones, roll cages, and safety glass, would increase cost and weight — and not improve safety. The weight and expense would slow the adoption of a transportation mode that is inherently safer than the status quo. Safety should not be judged in isolation, but as part of overall transportation safety. It would be a detriment to society if laws designed to improve safety actually reduced it. The most effective way to improve transportation safety would be to rapidly transition to Transit X.

Fair Fares

Transit X is developing a "Fair Fare" pricing model that enables a rapid, smooth, and equitable transition to a more sustainable mode of transportation.

Most travelers will pay much less than they are now paying for transportation and the cost should be comparable to existing mass transit fares. For example, a subway fare in

Boston costs about $2.50, and the average distance per trip is 5 miles (8 km) — an average of $0.50 per mile ($0.80/km).

A fare is based on the distance traveled, and the fare rate is based on the median income of the region, and the per capita usage of Transit X. The more that Transit X is used, the less expensive it becomes.

Fares will also vary based on service levels and local policies. For example, governments may subsidize part of all travel, and a shared pod might cost 25% less than for private (unshared) travel. Premium services may have higher pricing for service-level guarantees. There are many other possible pricing options. Only in highly unusual circumstances do we see the need for congestion-based pricing, as the capacity of Transit X is sufficient to provide congestion-free travel during daily peak periods.

The Fair Fare policy is a unique approach to pricing that assures affordability as well as profits necessary to fund a rapid transition to sustainable mobility without public funding.

Data Collection and Privacy

Enormous amounts of data can be captured, but reporting on a few key metrics is helpful to assess the health and operations of the system.

The number of passenger trips per day, the distance traveled by passengers and per vehicle, and average wait time provides a good base.

Visualizing use of Transit X on a map overlaid with population density can help identify regions that would benefit from an extended network.

For measuring safety, we can capture the number of unsafe conditions, and even capturing the number of unexpected conditions that might have led to an unsafe condition. There will be an entire safety management process designed to continually improve safety. The number of crashes and injuries that never occurred because travel was moved from road vehicles to Transit X should also be reported.

The reduction in CO2 and GHG emissions from transportation can be estimated from the distance traveled by passengers and vehicles.

Transit X will provide anonymized data to transportation researchers. Some real-time information may be shared with business partners to create and improve services to businesses and travelers while maintaining traveler privacy.

A policy will be developed to assure appropriate levels of privacy and authorized access comparable to existing modes of transportation and that adheres to local laws and regulations.

Alternatives

Bus Rapid Transit

BRT requires use of precious space on the roadway and sidewalk to achieve higher speeds.

Light rail or trolly

Light rail has much higher capital costs ($160-$300 million per km), higher operational costs, less capacity, and much lower convenience than Transit X.

Autonomous road vehicles

Compared to Transit X, self-driving electric vehicles provide significantly less capacity, require more parking, have lower efficiency, lower resiliency, slower speed, lower safety, higher cost, higher pollution, and far greater complexity. Major investments have been

made in autonomous cars by many vendors, but cost, complexity, and congestion will slow their adoption. Autonomous road vehicles will always need to contend with a shared rights-of-way with pedestrians, bicyclists, and non-automated vehicles. Technically, Transit X is a shared fleet of fully-autonomous electric vehicles — only riding under dedicated tracks.

Why now?

Transit X is most similar to Personal Rapid Transit (PRT), but no PRT systems have achieved widespread adoption. It is therefore important to understand why PRT has not been successful. First, PRT has not had the high capacity to replace mass transit. Second, although it is less costly than rail, it has not been able to be cost-competitive with roads and bridges. Third, although smaller than light-rail, PRT has had too large a footprint to operate on most streets. Fourth, the business models from PRT vendors have been to sell a system rather than operate a profitable service. These are four of the major issues that have prevented adoption of PRT and that Transit X has solved.

Car-free

Is it possible to be car-free? Yes. There are now hundreds of old city centers, hundreds of islands, and a handful of larger regions with a population of 100,000 to 200,000 people. Ilha Grande in Rio de Janeiro, Fes el Bali in Morocco, parts of Quebec City, Canada, and Venice, Italy to name a few. A comprehensive list of car-free regions can be found here:

https://en.wikipedia.org/wiki/List_of_car-free_places

Although most are relatively small regions. Transit X enables much larger regions to be car-free and pedestrian-friendly.

What is car-free?

"A car-free city is a population center that relies primarily on public transport, walking, or cycling for transport within the urban area. Car-free cities greatly reduce petroleum dependency, air pollution, greenhouse gas emissions, automobile crashes, noise pollution, and traffic congestion."

Source: https://en.wikipedia.org/wiki/Carfree_city

Car-free areas are more walkable and considered more desirable. Cars can be parked at the edges of a car-free zone where pods are always waiting to bring travelers anywhere within a car-free area.

Rapid Transformation

Is it possible to rapidly transform the transportation system of major cities? Yes, and it has been done before. The two photographs below both show 5th Avenue in NYC.

The photo on the left was taken in 1900 and shows the predominate use of horse-drawn carriages. Only one horseless carriage (car) can be seen. The photo on the right was taken in 1913 and shows the predominate use of automobiles. Only one horse-drawn carriage can now be seen.

If you had asked someone in 1900 as to whether NYC would be horse-free, most probably would have said "not possible", but thirteen years years later, it was.

The rapid transition was due to lower environmental impact, lower cost, and higher convenience.

All horse-drawn carriages in 1900 **All automobiles by 1913**

Stages of adoption

When planning for Transit X, consider three incremental stages for adoption.

Stage 1: Less Congestion

Identify multiple possible routes for a pilot. Each should aim to reduce congestion. At this stage, the Transit X network may consist of a single loop or line. Because of the network's limited coverage, the mode share is less than 10%.

Stage 2: Congestion Free

The goal of this stage is to eliminate congestion by minimally connecting all the major commercial areas within an area along main roads or secondary roads. At this stage, the mode share for Transit X might range from 10% to 50%.

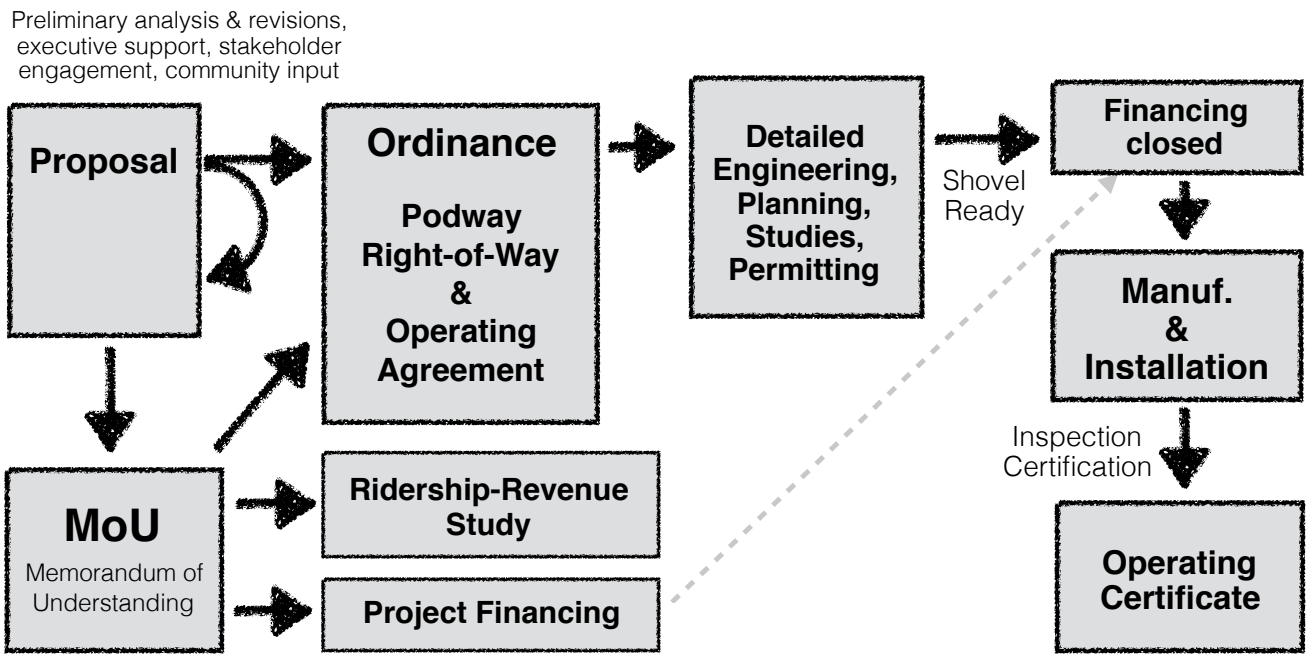
Stage 3: Car-free

A network that offers convenient access to most origins and destinations including schools, office buildings, and residential developments has the potential to be car-free. The mode share for this stage would be between 50% and 85%.

Next Steps

We hope this handbook has answered many key questions and will help you to develop a proposal to provide dramatically improved transportation in your area.

At any stage, feel free to email hello@transitx.com and provide some background information about your opportunity. Perhaps there are articles, reports, or studies that talk about the problems with the existing transportation system, or options that are being considered. Often, potential projects have been considered for years or decades, but the project has never been funded. Because Transit X is low cost and not dependent upon public funding, projects that were never financially viable may now be viable.



Independent Expert

It may be helpful for you to consult with experts who can provide an independent analysis and evaluation of a proposed Transit X network. The vast majority of urban and transportation planners do not have the requisite knowledge on this type of technology and will have a strong bias to recommend conventional forms of transportation such as buses, trains, and autonomous vehicles. A consulting firm should have experience with Personal Rapid Transit (PRT) or Autonomous Transit Networks (ATN). An expert should ideally have some knowledge of Transit X, as it is substantially different from other PRT vendors. A web search for "PRT ATN transportation consultant" may help you find possible consultants that can help you identify and evaluate potential solutions that fit your specific needs.

Project overview

Projects can take different paths, and is often complex. But in general, projects develop a proposal over a series iterations that builds the business case, identifies stakeholders, and finds sources of funding.

An initial project scope develops the potential routes, primary stakeholders, an economic model, and a letter of commitment. Then, a proposal is written describing the financing, rights-of-way, and the role of all stakeholders. After a signed agreement, detailed surveying and manufacturing begins, followed by installation and receiving a certificate to begin operations. The estimated time from a signed contract to an operational system is 24 months. A more detailed description of the process along with example documents can be found at **transitx.com/process**

There are many ways to approach a project. Reading this handbook has hopefully sparked some ideas for getting started and we hope to hear from you.