Handbook

A companion guide to proposals for sustainable micro-rail network — a fleet of automated electric vehicles (pods) for passengers and freight on a local and regional podway providing equitable public transportation

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

transitx.com/transitxhandbook.pdf
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Transit X™ is an equitable public transportation network with the capacity, convenience, and cost to rapidly supplant cars, buses, trains and trucks.

Background

Who is this document for?

This handbook is for people who want to learn how Transit X can address important transportation challenges in their city or region.

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

If you have more questions or would like to arrange a meeting, please email hello@transitx.com

Transportation Goals

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

Also, we all want less congestion, carbon/GHG (Greenhouse Gas) emissions, pollution, injuries/deaths, and taxes. We want more economic development and green space. We want improved access to jobs, health, resiliency, and quality of life.

The problems with our existing transportation systems are well known. Cars, buses and trucks place 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 only incremental benefits, and autonomous vehicles will likely increase congestion.

Transit X provides a public 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 is sustainable micro-rail with suspended featherweight vehicles — solar pods traveling under podways. Transit X is a 100% automated network providing high capacity,
non-stop, single-seat travel from origin to destination on an exclusive right-of-way. It is powered by 100% sustainable energy.

Our four-passenger pods (363 kg maximum), quietly cruise above traffic suspended from a narrow (300 mm) track. Destinations are entered, prior to boarding, through a mobile phone or touch screen at a stop. Passengers board a waiting pod at stops that are convenient located. Passengers enter a pod at ground level as they would a car. Landing areas take up half the space of a parking spot and can be located on the sidewalk or street. Pods are lifted up and then quickly accelerate to merge onto the main line, and then travel non-stop at 72 km/h (45 mph) until reaching the exit at their destination stop. It is a fully automated public transportation network with high-capacity interchanges that provide fast, congestion-free travel. Transit X has a zero net footprint on roads or sidewalks — and enables roads and parking lots to be used for other purposes.

Our first public demonstration was on October 29, 2018 and a number of projects have started in the United States, Africa, and Asia. We anticipate breaking ground in 2019 and that our first systems will be operational in 2020.

We aim to 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 is affordable and equitable public transportation. We can arrange financing for most projects because its low-cost makes it profitable.

**Technical Overview**

Each pod is self-powered and fully automated. Each pod has a 10 kg (22 lbs) battery that powers electric motors and four polyurethane-coated wheels that run along micro gauge 300 mm (12 inch) titanium rails. The pod’s cabin is suspended below the rails. The rails are protected from the elements inside fiber-composite beams supported by fiber-composite poles located approximately 23 m (75 ft) apart. Stops are off the main line on sidings.

Transit X uses proven materials, technologies, components, and processes from other industries. In many ways, Transit X is similar to cars on roadways. We have avoided higher risk and higher cost technologies such as magnetic propulsion, underground tunnels, or evacuated tubes.

The control system is more similar 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 that weighs 34 kg (75 lbs). There are three major pod types: a roll-on pod, car pod, and cargo-pod. The roll-on pod has a door height of 1450 mm (57 inch), a flat bottom, and a split-folding rear seat. A roll-on pod can hold a stroller, wheelchair, bicycle, or gurney, along with two passengers. The car pod has a front and rear compartment, each with a bench seat, and carrying 4 large adults or up to 8 children — a a maximum passenger load of 450 kg (1000 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 1000 kg (2200 lbs).

The network is all-electric and is 100% powered with sustainable energy. Solar film covers the tops of pods and solar panels can be affixed to the track to generate energy which is then stored in large batteries housed inside the support posts. Pods park where energy is available and charge while stopped or parked. Small vertical wind turbines may also be used. Transit X may also get power from sustainable energy sources on the grid.
**Handicap Accessibility**
Transit X offers the same high service level for people of all abilities. Pods descend to ground level, providing easy access via roll-on pods that enable passengers in a wheelchair along with a rear seat for two additional people. Visually impaired 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 are guaranteed to arrive simultaneously at the destination. A roll-on pod can carry a full-size bike, skis, stretcher, or surfboard, along with a passenger.

**Door-to-Door**
Transit X provides door-to-door travel to the final destination (also known as “last mile” — without roads and cars. Stops cost less than a one-car parking garage and can be as close as 23m (75 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 six pods per shuttle. Pods transition from local to high-speed track using automated interchanges. All boardings occur at local stops so there are no high-speed stations.

**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 1000 kg (2200 lbs) and fit a standard 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 most trucks on city streets. The scheduled arrival for a pod could be guaranteed within one minute, eliminating the need for many loading docks and storage areas.

**Final freight recipient**
Transit X can provide final delivery of goods and packages to individuals and businesses. Freight pods can deliver pallets to existing loading docks. Individual packages can be securely handed to passengers as they exit a pod. Alternatively, automated carts can carry loads from a stop to the door of a residence or business.

**Proven concept**
Transit X is a new design based on a proven system that has been operating for 40 years in the United States. In Morgantown, West Virginia, the University of West Virginia has been operating a personal rapid transit system that has maintained a near-perfect safety record 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 several of these automated transit systems.

The Transit X system is comprised of well-proven subsystems that have been used in other industries for decades: wheels on rails, carbon-fiber shell, fiber-reinforced structural beams, and an elevator-like control system.

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 its headquarters is in Boston, Massachusetts, U.S.A. Transit X has a test and assembly plant located in the Boston area.

Proposal Handbook
If you are reading this, you are likely interested in ways to improve transportation, and see Transit X as a potential solution. This handbook aims to strike a balance between clarity, conciseness, and completeness. We hope this handbook provides answers to many questions that enables you to move forward with a project.

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. Transit X makes Development Oriented Transit (DOT) possible where public transportation can be easily extended to most locations.

For example, when transit infrastructure can be easily added and at relatively low cost, it enables the transit infrastructure to be easily extended to new locations. 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 without the use of a car.

Because routes can be easily added or moved, Transit X requires significantly less long-term planning than conventional mass transit — it’s more similar to planning a bus route.

Transit X networks can scale from a short pilot line to an expansive road-like network. An initial network can be sketched out in a few hours. Here’s a straightforward approach that we’ve used when planning networks.

Identify demand
First, identify the places where people live, work, and play. This can be done with satellite maps, traffic overlays, transit and bus routes, or perhaps existing transportation studies. On a satellite map, color and texture are useful to locate areas that need to be served. The location of buildings, parking lots, and transportation routes are all helpful to mark.

Most light-rail is extremely costly at over US$93M/km (US$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 exception). Transit X is much less costly than light-rail, and similar in cost to roadways. Transit X runs on exclusive rights-of-way (RoW) easements that don’t interfere with vehicles or pedestrians. Routes typically go along corridors where there is existing pedestrian traffic and high demand for convenience access.

Stop 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" and two landing areas fit in the space of a parked car. 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 can be easily added when necessary — even after a system has been put into operation. An individual stop may even be privately financed. A single landing pad provides about 300 boardings per hour, and stops can scale to accommodate 3,000 passengers per 10 m (10 yards) of curb space.
Parking
Many train stations have large parking lots, but 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
Pods can be easily added as demand increases, and the system can help forecast when more pods should be added to satisfy demand.

Aim for car-free
We recommend that you 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. For a car-free metropolitan area, 90% of the population should be within one or two blocks from a stop — less than a 4-minute walk.

Pilot
A 30 to 40 km (18 to 25 mile) pilot project is recommended, and we recommend identifying several potential routes. 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. We look to work with the local utility companies to relocate existing power and utility lines along the sides of the tracks.

Transit X professionals and their local partners can help guide you through a short and productive planning process.

Rights-of-way
Acquiring the necessary rights-of-way (RoW) easements is necessary before a project can begin. 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 stakeholders.

Land Use
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, 300 mm (1 ft) wide and 600 mm (2 ft) tall. Each stop has one or more landing areas of 1.2 m (4 ft) by 2.75 m (9 ft). 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.
Columns
300 mm (12 inch) diameter columns 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 along the tracks to run power or telecommunication cables. Pole extensions may also be used to attach high-voltage power lines above the tracks. Transformers and other equipment may be mounted on our poles. We work with local utilities to relocate and incorporate cables within the tracks.

Trees
The project team works with stakeholders to determine the best approach for keeping the existing trees and dramatically increase green space from land reclaimed from parking areas and roadways.

Legal
The legal right-of-way will often take the form of an easement along public rights-of-way (RoW). 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 owners receive a percentage of revenue. The use of eminent domain has often been necessary for building new roads and railways, but most Transit X projects will never need to use eminent domain.

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.
Road RoW
Along public roads, the podway columns may be located near the curb along a sidewalk, on a bump out, or along the middle of the road on a median strip. It is also possible to attach them directly to the side of buildings. Roads may be owned at various levels of government.

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.

Railway RoW
A podway would not impact the existing use of a railroad RoW but legal and liability concerns are often a major concern when getting permission to use railway RoW for a podway.

Crossings and Steep Grades

Bridges
An elevated podway 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 several different types of bridges to enable crossings of various lengths, heights, and depths.

Steep slopes
A standard Transit X track can support a maximum of 27% grade slope (15 degree), but other track configurations can traverse slopes of any grade.

Earthquake and Flooding
The system will be designed to meet all local codes for earthquakes and other requirements.

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 line and boarding areas. A system's capacity is designed to handle the demand at some level of service.

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

A single Transit X track provides 30,000 passengers per hour per direction (pphpd), the equivalent capacity of 16 highway lanes. In most cases, this capacity is sufficient for any demand, and where more capacity is needed, more tracks can be added. Achieving high
capacity for roads and rail is much more difficult because of the exorbitant cost and limited space.

Estimating demand for conventional transit can be complicated, difficult and error prone. Fortunately, the standard configuration for Transit X provides a high level of capacity and adding (or removing) capacity takes only months. This dramatically simplifies the planning process for projects. Accurately estimating demand is challenging and estimates are often inaccurate. 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 likely increase during those hours from induced demand.

Adding additional Transit X pods to meet demand is simple. Unlike most transit systems where adding new trains and changing schedules can take years, adding additional pods takes only days or weeks. Transit X is “zero wait”, so there are no schedules that need to be updated.

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 accommodate in a given period of time, with a unit of maximum passengers per hour per direction (pphpd, or pph for short). Capacity can separated into line capacity and boarding capacity.

Track Capacity
Line capacity is the number of people that pass through some point. For Transit X, maximum capacity for a single track is 30,000 pph — the equivalent of 16 highway lanes. This assumes shared pods with an average of 2.7 passengers per vehicle and pod trains with three pods per train.

Three factors enable such high capacity:
1. Automated pods can safely achieve a 1 second headway. Cars average 2 seconds.
2. Pods are more easily shared to double (or triple) the average vehicle capacity
3. Pod trains (multiple pods coupled together) dramatically increase the capacity

If there was a critical need, such as during an evacuation, pods could be filled to capacity and form trains of six pods to achieve 100,000 pph.

Boarding Capacity
Boarding capacity is the number of people that can board (or exit) at a station or stop. For Transit X, a single lift at a stop enables a pod to board (or empty) every 10 seconds on average, for a boarding capacity of 360 pods per hour, and 720 passengers per hour (pph) assuming 2 passengers per boarding.
Boarding capacity at a Transit X stop is scalable. Two stops fit within a single car parking space, and 10 m (10 yards) of curb space supports 2,400 passenger boardings per hour assuming 2 passengers per boarding. Stops can be easily added to the network.

**Junctions and Interchanges**

Transit X provides several types of interchanges including a “Circle” (similar to a rotary or roundabout), a diamond, and an Umbrella™ — a new type of 3-D junction. All types can fit 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). All junctions are composed of Wye (“Y”) merges with no intersecting tracks.

![Transit X Junctions](image)

Parking

When not in use, pods are parked along track sidings or in a high-density automated garage. 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. Pod Garages do not occupy any footprint on the ground other than their support columns. The total volume of a parked pod is 4.4 cubic meters (155 cu. ft.)

Revenue

Most transit systems operate at a loss, but Transit X has extremely low operational costs that enables systems to be operate profitably.
The majority of revenue comes from fares, freight, and advertising. 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. No exterior advertising on tracks or pods is allowed, unless required by government authorities.

**Risk mitigation**

Transit X has remove many of the risks associated with mass transit systems. With near zero disruption, extremely high safety, low cost, and fast construction times, Transit X represents a low-risk options. Over 100 automated transit systems are in operation around the world, including a personal rapid transit system in Morgantown, West Virginia that has been in operation for 50 years with a nearly perfect safety record. While Transit X may look a lot different from these other systems, the underlying design is well proven.

A public demonstration of Transit X was shown on October 29, 2018 in Leominster, Massachusetts. The first systems are expected to break ground in 2019 and begin operations in 2020.

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.

There are significant risks in continuing with existing transportation systems. 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 due to congestion
- Health risks due to poor air quality
- Cost overruns on large infrastructure projects
- Rising bond rates for financing expansion
- Disruptions from construction
- GHG emissions from transportation

Transit X provides all financing so that governments are not taking any financial risk. Our partners in civil engineering, automation controls, and energy each guarantee their work and all Transit X projects are fully insured. All systems are safety-certified before starting operations. Transit X achieves a much lower risk than any other option — including continuing with the existing transportation systems.

**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 several orders of magnitude smaller, quieter, and cleaner and therefore the
objections to conventional elevated transit do not apply. The public meetings for our projects have been met with high levels of support from the local community.

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

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. Approximately 1/3 of the land area in most cities 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 leaking 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.

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

Elevated systems are often taken down, because they lowered the quality of life — the noise and vibrations from the trains were significant. 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 improve aesthetics. The columns, 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 option for hiding power and other utility lines within the tracks.

**Privacy concerns**

Transit X offers greater privacy than current roadways, because the pods travel non-stop at 72 km/h (45 mph) and have obstructed side views, eliminating the potential for gawking. The viewing height from a pod is not significantly 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.

**Organizational structure**

Transit X has overall responsibility for all aspects of a system including Design, Build, Finance, Own, Operate, Maintain (DBFOOM). A Special Purpose Entity (SPE) is created to finance each project. In some cases, the SPE will be a Public Private Partnership (P3).

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.

Transit X believes in providing good jobs with good wages. When possible, Transit X uses local companies and workers for manufacturing, construction, design, maintenance, and operations. 75% (seventy-five percent) of Transit X profits are invested into local projects to provide equitable transportation throughout a region.

**Procurement**

Conventional transit systems require a public procurement process because they require public funding. Transit X typically provides private financing, the typical Request for Proposal (RFP) process may not be necessary.

**Costs**

Transit X is privately-financed without the need for government funding. Transit X podways are an order of magnitude less costly than light rail, and much lower cost than building roads or Bus Rapid Transit (BRT). Transit X typically costs less than maintaining the existing roadways.

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

**Capital costs**

The capital costs for Transit X are approximately US$4M per km ($6.4M 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 a small fraction of the material in railways or roadways of the same capacity.

The track has no moving parts, and there is no electrified rail. Each pod has only a small number parts, and 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, fuel, and maintenance make up the majority of operational expenses for most rail or bus systems. As Transit X is fully automated there are no driver salaries. There is no fuel cost, and the energy cost for generating sustainable power is typically included in the capital costs. In addition, the pods have only a handful of easily replaceable parts, and the columns 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**
Each Transit X proposal (see transitx.com/proposals) has a financial model that calculates the expected internal rate of return (IRR) for a proposed system. A table of assumptions provides default values for fares, interest rates, split between debt and equity, length of loan, etc.

**Financing**
Capital costs are financed with equity and debt through commercial loans, private equity, government programs, local funding, and/or private bonds. Transit X works with investment banks, private equity firms, developers, commercial banks, and government to secure project financing. Transit X also finances projects from regional project investment funds.

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

Touch screens will be mounted on posts at a stop. These interactive screens, 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, hand print, and facial recognition. 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.
Accessibility
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
Construction on typical transportation 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 major disruption is the digging of holes for the posts, 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 posts 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 greenhouse gases — slowing or perhaps even reversing global warming if widely adopted.

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

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 57 kg (125 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.

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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.

**Safety**

Every year, there are over a million deaths and hundreds of millions of injuries on roads worldwide. In the airline industry has achieved a much higher level of safety. 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 location 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 and the absence of heavy vehicles makes the system inherently safer. The pods use small batteries and don’t include 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**
Transit X is grade-separated which means there are no at-grade (ground-level) 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 rear compartments, so that all vehicles can be safely shared with another person. In addition, sharing is optional and a personal preference.

**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 into another pod or 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 one million 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 achieved a nearly-perfect 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 has developed a “Fair Fare Formula” regulated 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 Formula 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 trolley**
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.

**Phases of Adoption**
Transit X can be incrementally adopted through a series of phased expansion projects. The construction time for each expansion project would be short (12 to 18 months).

**Phase 1: Access to key destinations** (20-40 km)
A Phase 1 network should provide access to key destinations such as employment centers, retail centers, transit hubs, schools, hospitals, entertainment venues, airports, and tourist attractions. Many people would no longer need a car and individuals could decide to go “car-free”. For areas not conveniently served by Transit X, cars or other small vehicles could be driven to any stop with available parking. The traffic congestion on roads and highways would be significantly reduced.

**Phase 2: Within 10 minutes of a stop**
As Phase 1 starts operation, Phase 2 should begin. All major origins and destinations should be located within a block of a stop. In low-density areas, stops would be within 10 minutes of a stop. Many parking areas would be empty and available for new development. Lanes could be dedicated to bicycle and pedestrian uses without upsetting car owners. Transit X would provide between 20% to 60% of all trips. All traffic congestion would be eliminated. No one would need a car to get around the city and everyone could decide to go “car-free”.

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Phase 3: Within a block of a stop
A fully built out podway network across a metropolitan area would provide between 60% and 90% of all trips. The vast majority of trips would be convenient with Transit X. The width of most roads could be reduced to 4 m (12 ft) and on-street parking spaces could be converted to green space. Many areas could be designated “car-free”.

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.

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.

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