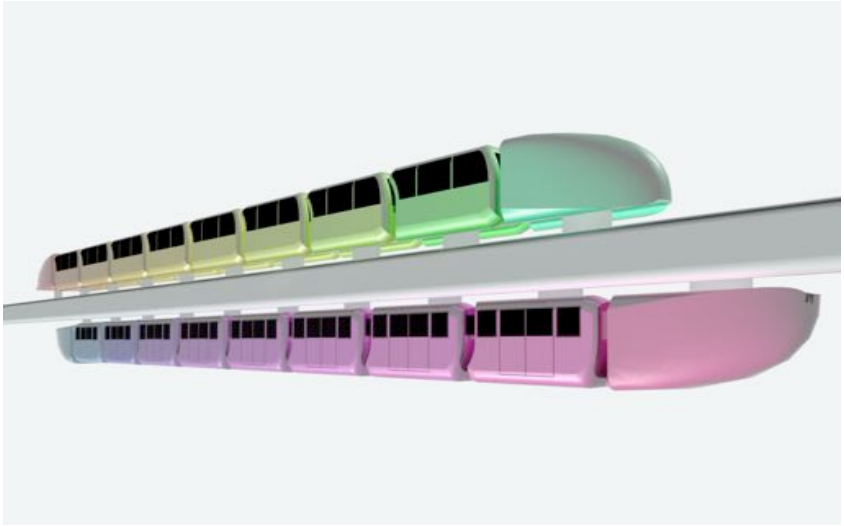
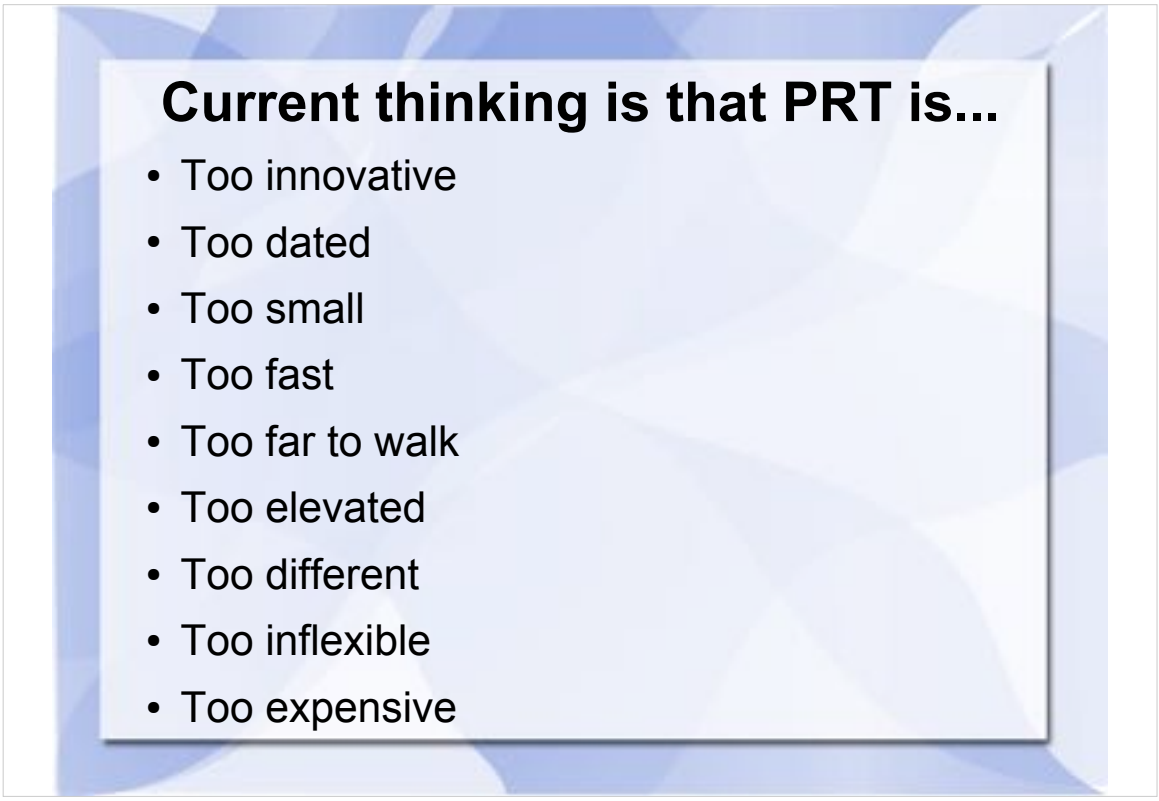
Lofty Taxi



My journey into PRT, started when Ottawa' BRT system was reaching capacity and a search for a new transit system was undertaken by the city. After years of investigation of the available systems, it became clear that nothing was quite up to the task. So I began designing a new PRT system.

Lofty Taxi, see LoftyTaxi.com, is a high-capacity, high-speed PRT system design.

By François Allard: inventor, B.Sc.(hons)
Francois.Allard@LoftyTaxi.com



Is it too innovative?

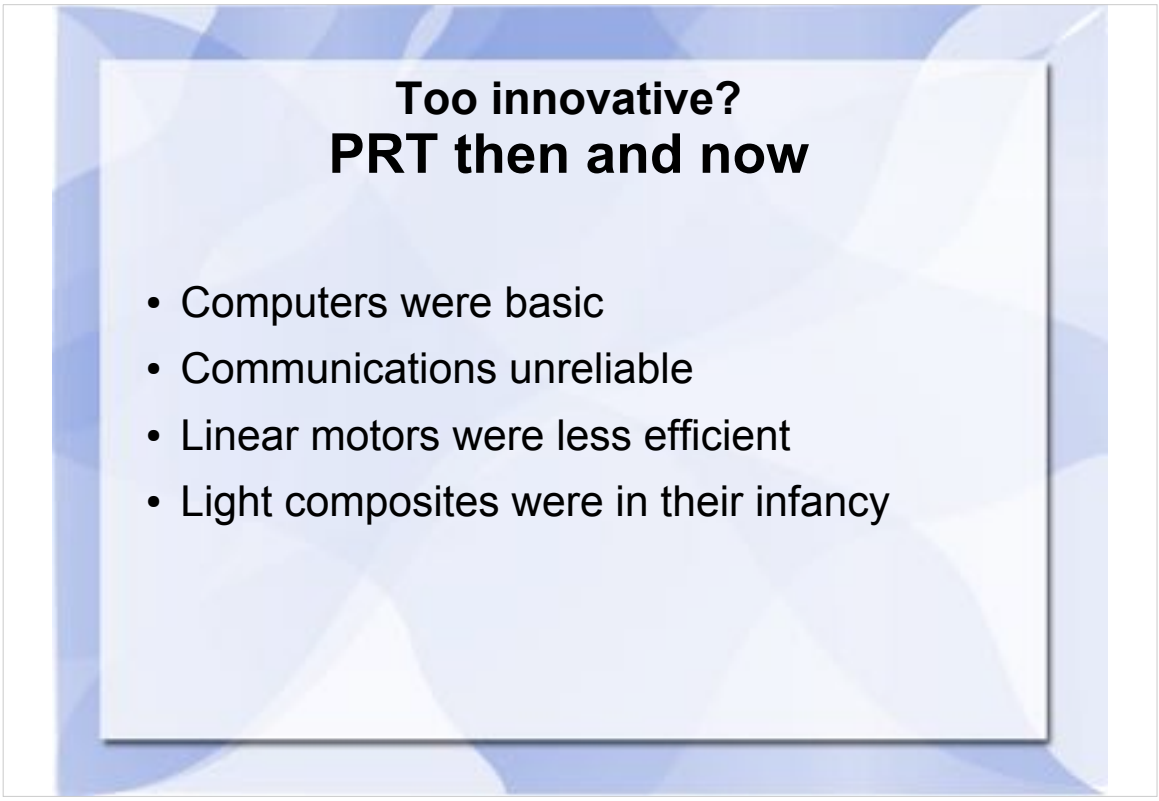
Cabinentaxi, see http://faculty.washington.edu/jbs/itrans/cabin.htm, for example, was ready for revenue service in the 1970s. A full track was built and the system tested, so we know PRT can be built. More modern examples of PRT also exist such as 2getThere, ULTra and Vectus.

Too innovative?

Timex Sinclair - 1982

By User Carlb on en.wikipedia derivative work: Ubcule (talk) - Zx81-timex.jpg, Public Domain

This was my first computer, a Timex ZX-81 – introduced in 1982, it had 2 kiB of RAM (equivalent of about a half page of unformatted text) with magnetic tape storage. I would describe it as flaky – the power supply connector *glitched* out if bumped and lost programs and the tape drive was unreliable at best. Granted this was a consumer item, but it illustrates “the state of the art” at the time. It cost $100 USD which is about $250 today. Things are measured in Gigas today, not kilos, so a million times more.



Things are better now:

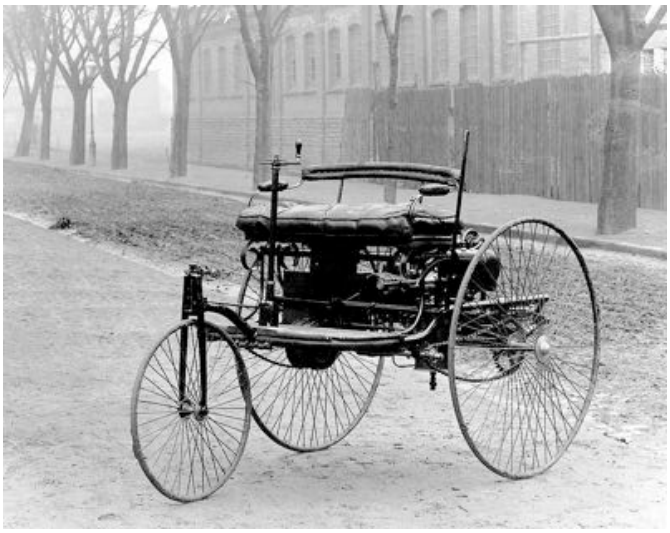
- Computers, needed to coordinate and guide vehicles, are inexpensive and fast. This also makes software cheaper, easier to write and test.
- Communications, which relay position and other information, is now reliable, high-bandwidth and inexpensive making vehicle control systems simpler.
- Linear motors are more efficient making them smaller and cheaper.
- Light composite materials are becoming mainstream

So we could build it then and we can build it better and cheaper now.

Trepidation about automated systems was, understandably, much higher in the past, where today, driverless cars are seen as within reach and desirable. Tesla motors now promotes its cars' limited self-driving ability, though they must still be overseen by a responsible driver.

Too innovative?

Karl Benz first motorcar - 1885



Karl Benz the inventor of the motor car, 1885, Public Domain

The first motor car was built in 1885. It took decades to mature into what is more recognizable today.

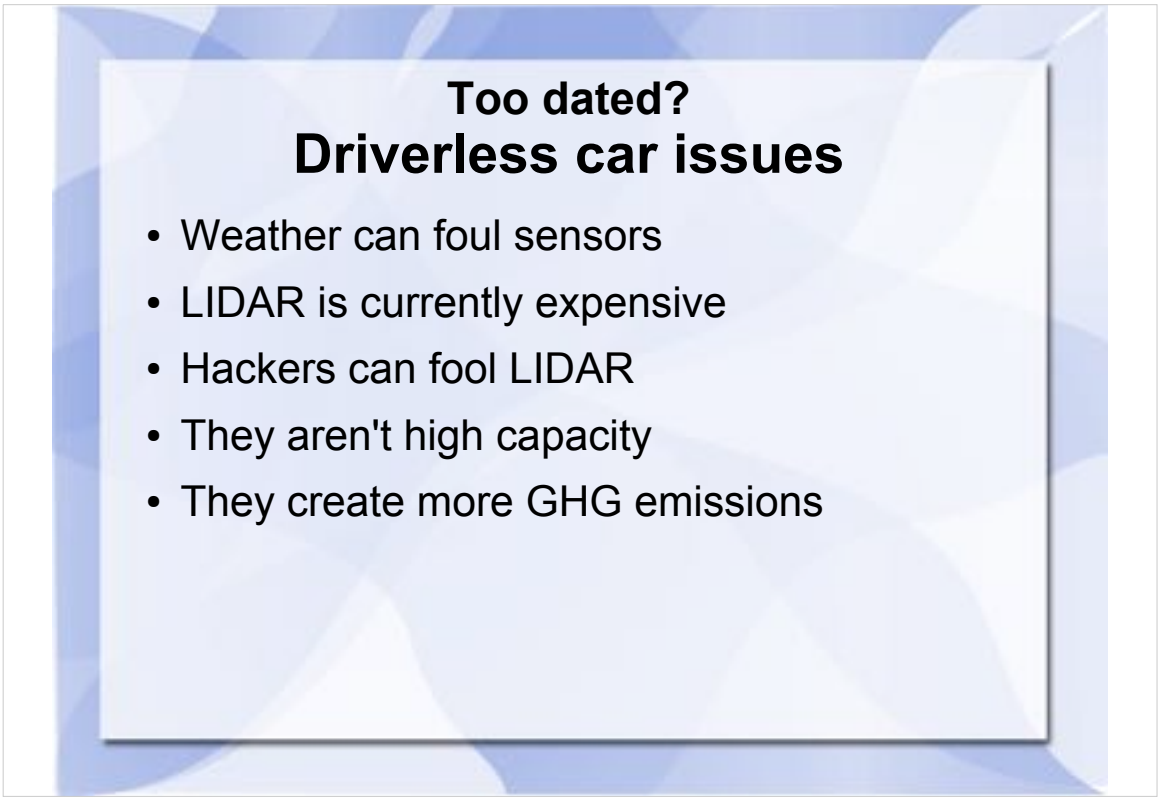
PRT may have been ahead of its time when introduced, but today, the technology is fairly commonplace.

Too dated?

By Steve Jurvetsonderivative work: Mariordo - This file was derived from Driving Google Self-Driving Car.jpg:, CC BY 2.0

Is it too dated?

Some feel that PRT is not needed because driverless cars, like Google's here, will **assume that role**, but have driverless cars matured enough?



One of the issues with driverless cars is weather. Weather can foul sensors and create situations where driverless cars would be unsafe. Driving on ice and snow is also a challenge.

Lofty taxi uses almost fully enclosed linear motors to provide all weather traction and regenerative braking. It also knows the position of every vehicle on the guideway.

Google's cars currently use a LIDAR system which is expensive:

“For instance, LIDAR alone costs around $75,000. Prices as to the whole setup cost around $150,000. “ - http://googlesautonomousvehicle.weebly.com/technology-and-costs.html

but prices are expected to drop with mass production eventually.

Another point is that -

“Hackers can trick self-driving cars into taking evasive action. The Lidar sensor can be fooled into seeing fake people, cyclists, cars or walls with a $60 system built out of Raspberry Pi and a laser pointer” - https://www.theguardian.com/technology/2015/sep/07/hackers-trick-self-driving-cars-li

Lofty Taxi doesn't use expensive LIDAR. It runs on an elevated guideway away from most obstacles making the detection task simpler.

Too dated?

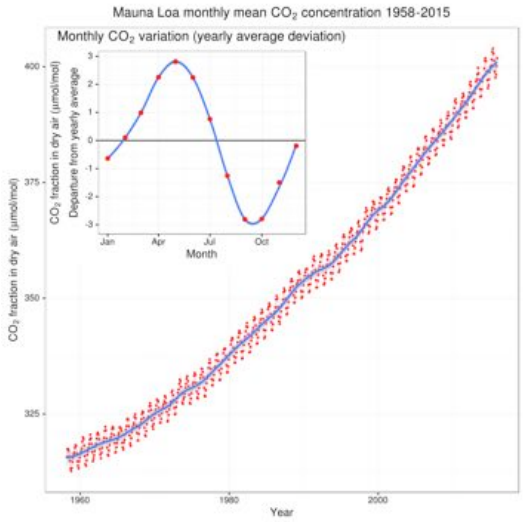
Highway 401 in Toronto

There has been talk of driverless cars reducing the number of cars. This is likely true because sharing is made easy when cars drive themselves. BUT, traffic will increase because cars will travel empty extra distances to pick up other passengers. The same thing happens with trains, buses and taxis and it also happens with PRT except that PRT runs on its own infrastructure and so doesn't add to congestion. Buses and LRT add to traffic congestion in other ways as well because they are often encroaching on road space, reducing available car lanes. They also hold up traffic momentarily while picking up passengers in the case of buses or crossing intersections in the case of LRT.

So, driverless cars aren't up to the task of providing high-capacity service whereas Lofty Taxi has capacity matching and exceeding LRT and BRT.

Too dated?

Mauna Loa CO_2 1958-2015



By Delorme - Own work. Data from Dr. Pieter Tans, NOAA/ESRL and Dr. Ralph Keeling, Scripps Institution of Oceanography., CC BY-SA 4.0

Fossil fuelled driverless cars run as taxis, would cause more GHG emissions because they travel further to accomplish the same trips. So like other cars, they need to be emission free. Hydrogen has a poor energy efficiency cycle and storage issues. Batteries are expensive and currently cost more on a vehicle lifetime cost comparison. These are predicted to reach parity with fossil fuels by 2020.

Life cycle analyses of the GWp of Li-ion batteries show that they contribute significantly to the emission footprint of road vehicles. Depending on the study, between 1.5 to 3.3 L/100 km worth of CO2 is emitted. Better than ICE, but not ideal.

Lofty Taxi vehicles get their energy directly from the guideway.

Driverless cars will roam our streets unassisted in the future, Lofty Taxi can be built now, in a time frame similar to LRT. Though it is true that some development and testing work must be done beforehand, deployment of elevated sections is faster resulting in a similar timeframe.

Too small?

2getthere and www.2getthere.eu

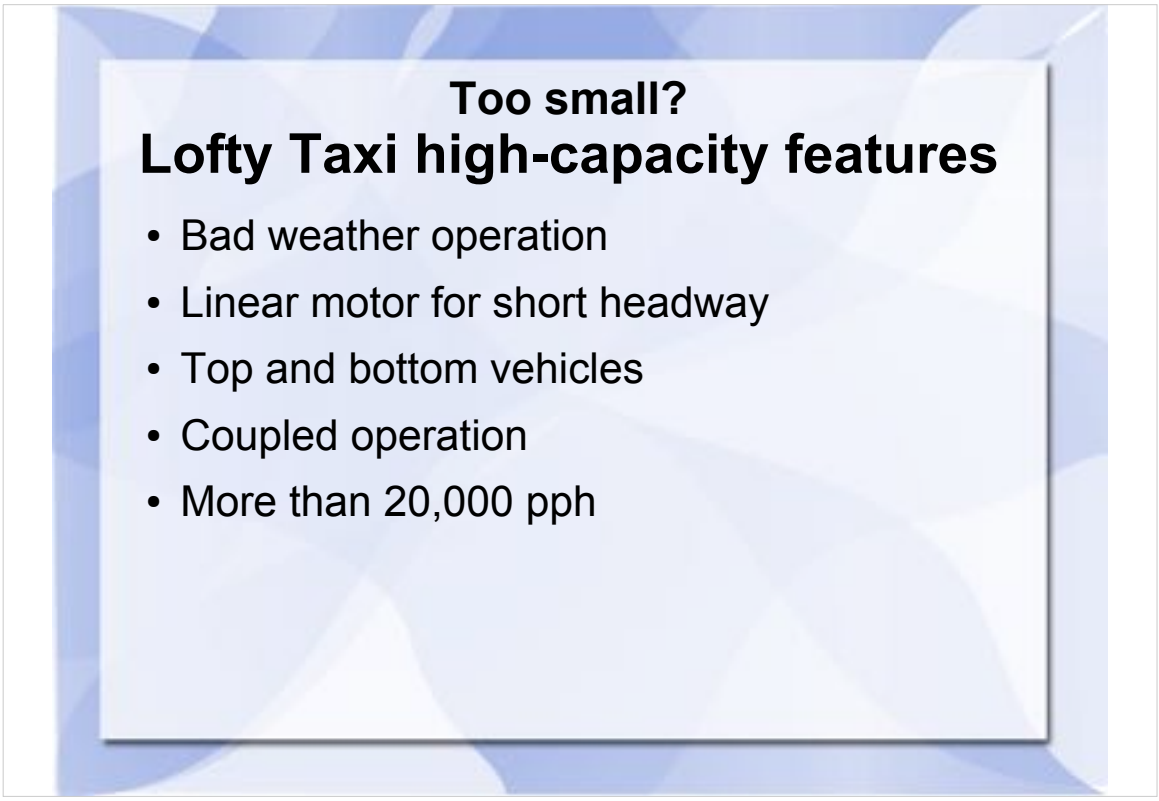
Is it really too small?
“You and yours travel together” as in this example by 2getthere in Masdar.
Small, yet, ironically, spacious compared to filled Mass Transit vehicles.

Too small?

A full metro in Taipei

By Richy - Chinese Wikipedia, CC BY-SA 3.0

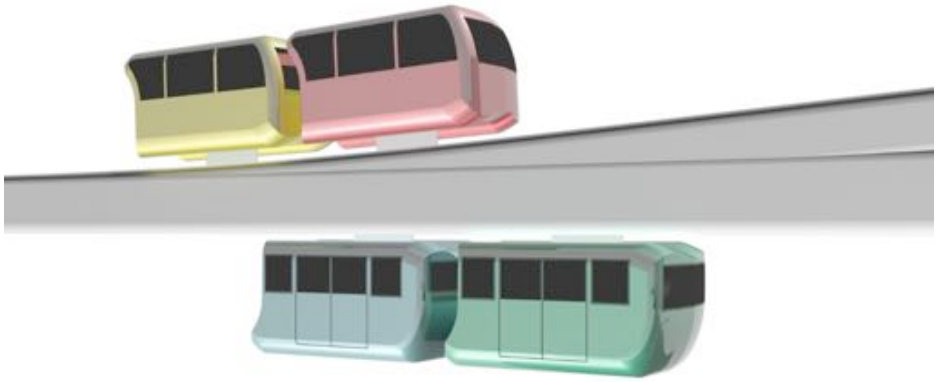
There is a belief that small vehicles can't possibly deliver high capacity, yet presently, most transportation of people is by car – a small vehicle.
Lofty taxi has many features which enable high capacity:



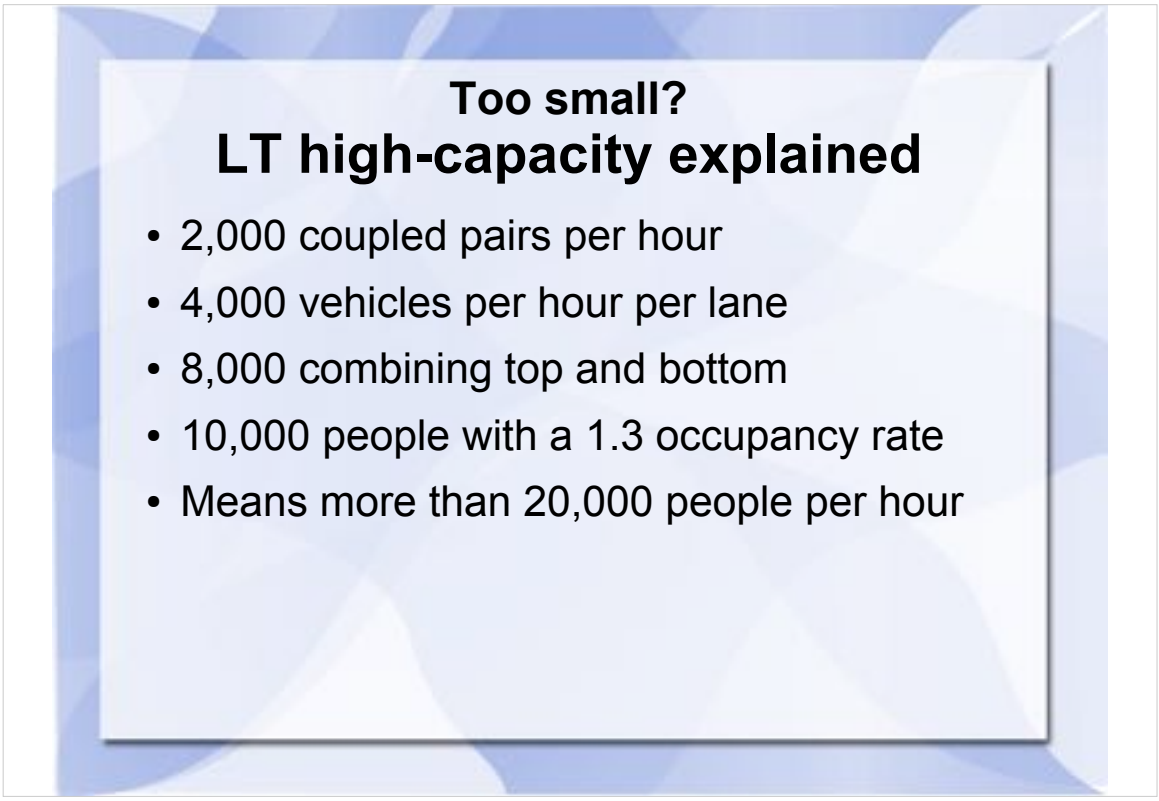
A weather guarded rail
A linear motor for guaranteed traction
Top and bottom running vehicles

Too small?

Lofty Taxi coupled vehicles



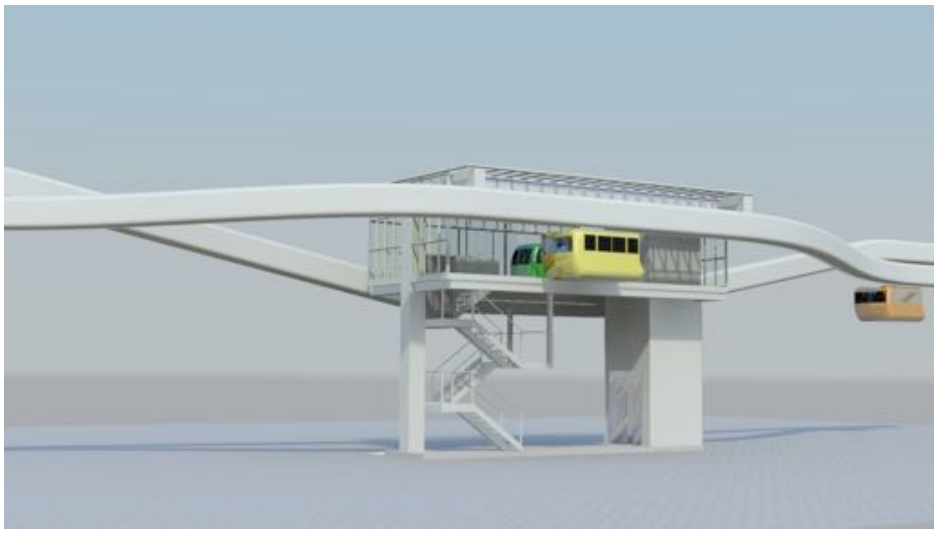
Coupled operation. Coupled operation is where two podcars are virtually linked (they run bumper to bumper) and are only allowed to split up at diverge points where each vehicle leader and follower has its own track and so no possibility of energetic collision. Merging is done at bumper speed typically in stations.



Combining all these features allows headways of 1.8s at 45 km/h. To put this into perspective, 2 seconds is considered safe driving separation at 100 km/h on highways but measurements show in excess of 2000 vph (1.8 second headway) per highway lane at much higher speed. So 2000 pod couples per hour per lane is over 8000 vehicles per hour per direction. Given a conservative occupancy rate of 1.3 passengers per vehicle, we get over 10,000 passengers per hour per direction. In the Mass Transit world, that's over 20,000 pph.

Too small?

Lofty Taxi station



Unlike Mass Transit, stations for PRT aren't concentrated because of specific transfer points. PRT would have many more, smaller, stations in the city core than a Mass Transit system would which means arriving closer to destination.

This small station (pictured here) can handle up to twelve-hundred (1200) vehicles per hour and around fifteen-hundred(1500) passengers per hour. Larger stations can handle more, but depending on the scenario, opting for more, closely spaced stations, would mean better service. The footprint of this station is the length and width of a regular city bus.

Too small?

Stadium

By Sterling - originally posted to Flickr as UTEP Sun Bowl, CC BY 2.0

But what about the stadium emptying scenario? A way to do it is to have an inexpensive, manned when in use, at-grade station. Essentially a section of guideway brought down to grade. This allows movement of very large numbers of people by filling every seat, up to 6,000 vehicles per hour means 18,000 seats are moving in each direction. Four directions means up to 72,000 seats per hour. More than enough for most applications.

Too fast?

By Madcap - Own work, Public Domain

Is it too fast?
Large trains routinely travel at over 300 km/h even in adverse weather.
Some say small vehicles can't possibly go fast?

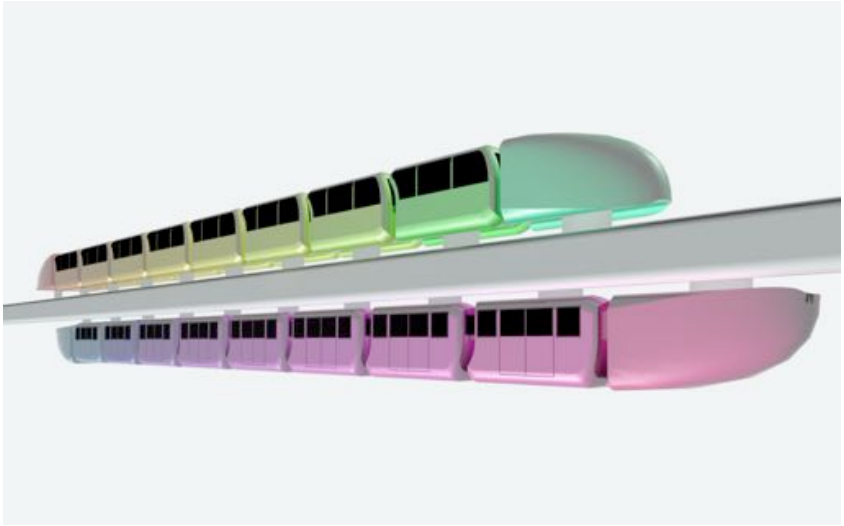
Too fast?
Audi S5

By Thomas doerfer - Own work, CC BY 3.0

Many Cars already routinely travel at 250 km/h

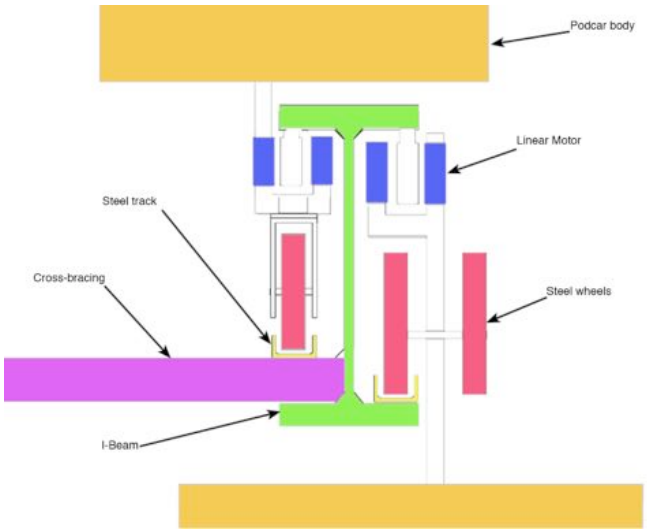
Too fast?

High-speed Lofty Taxi



Combine a smooth, enclosed rail with small vehicles running in trains and we have High Speed Personal Transportation for intercity travel.

Too fast?
Lofty Taxi technical



Lofty Taxi uses energy efficient Linear Switched Reluctance Motors instead of small wheels to provide guidance for its vehicles, so high speeds are possible without destroying bearings and wheels, and maintenance is greatly reduced. Switching via dual-sided linear motor is patent pending. Magnetic forces are used to guide a vehicle through a merge or diverge.

What if nature calls? No problem, on the limo version – think private jet facilities. Smaller vehicles will make “pit” stops on demand.

What is “the limo or long version”? It is a vehicle which is double-length. Since LT is designed to handle small vehicles running in pairs, larger double-size vehicles can also run on the guideway. These vehicles are used for larger groups, heavier loads and to provide “facilities” for high-speed travel.

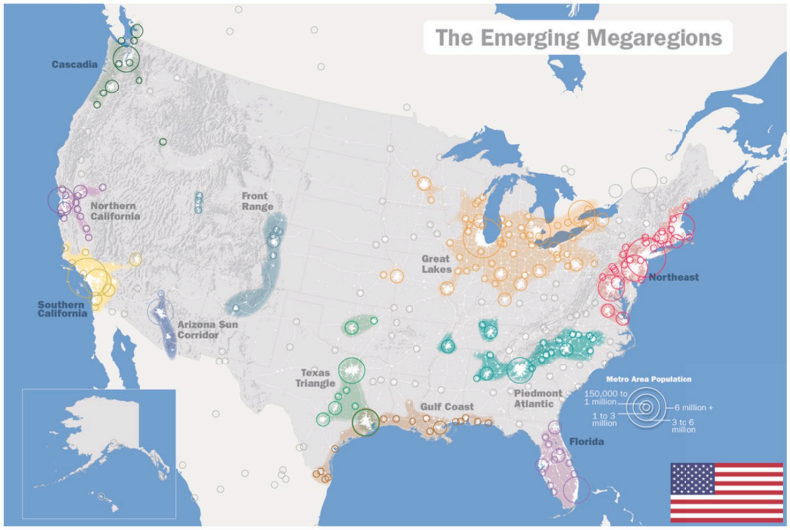
Too fast?
Windsor to Québec city corridor

By Carte_administrative_du_Canada.svg: STyxderivative work: Vidioman (talk), CC BY-SA 3.0

The Windsor to Québec-city corridor is home to over 18 million Canadians. There has been talk of a High Speed rail line along this corridor for decades. The studies always determined that value just isn't there. Maybe a personal vehicle transportation and a smaller investment alternative would fit the bill? Add in the cargo possibilities and we have an offering that makes sense in the North American market.

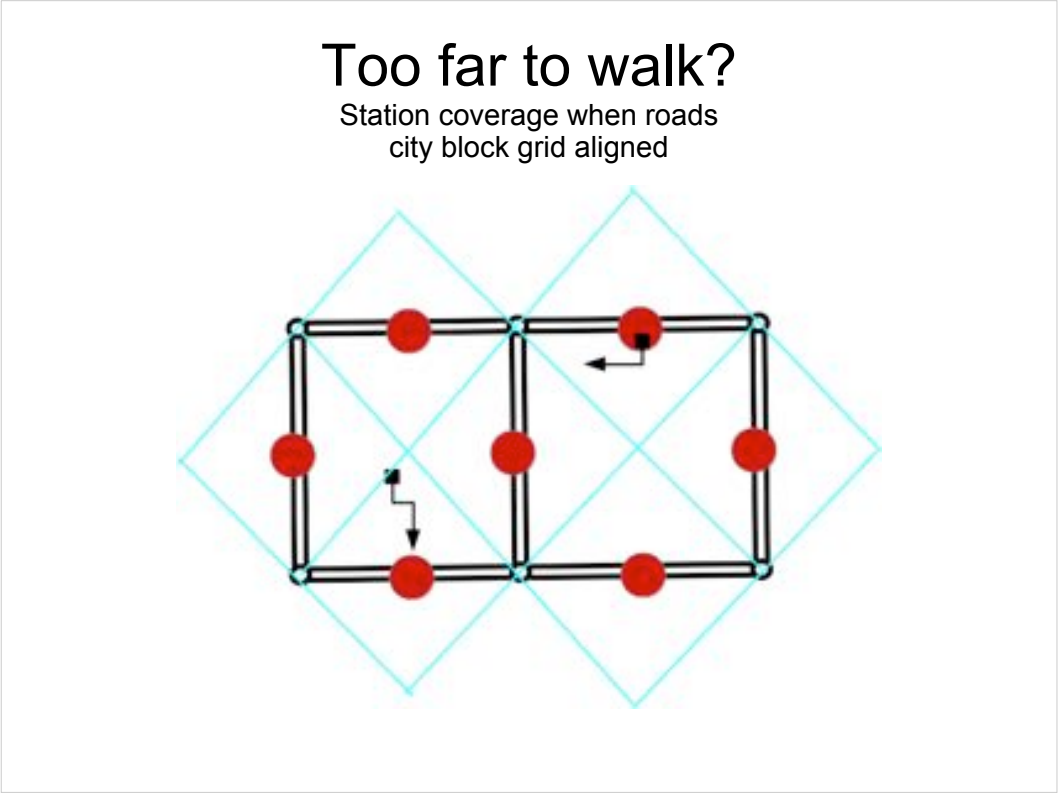
Too fast?

Corridors linking megaregions



By IrvingPINYC - Own work, CC BY-SA 3.0

Similar Megaregions and corridors in the USA also exist such as the Texas Triangle, the Boston to Washington D.C. Corridor and the controversial CAHSR corridor.



Is it really too far to walk?

The baseline grid for Lofty Taxi is a maximum of 800 m (1/2 mile) blocks with stations placed mid-block

This means that all point are accessible within 400 m, less than a 5 minute walk and half of the area is accessible in less than a 3.5 minute walk.

We won't spend any time talking about the health benefits of walking a few minutes. The good news is that once at the station, there is little to no delay. Podcars are either waiting or arriving shortly.

Too far to walk?
Driverless mini-bus

By Patrick Despoix - Own work, CC BY-SA 4.0

As an upgraded service, small buses, driven or driverless, like this DL citymobil2, can pick up passengers on call in a station coverage area and take them to the nearby station and then back.

Other possibilities include golf-carts to get to and from the station which introduces some parking requirements, though minimized by the small EV size. Mobility devices or bicycles are also an option, since the larger bottom vehicles are wheelchair accessible.

One way to make the walk more worthwhile is to offer value-added services at the stations – mail and package pick-up, large vending machines, maybe even a beer dispenser?

Based on various studies, modal split for PRT would be around 25%, PRT isn't expected to replace all trips, many people will continue driving.

Too elevated?

By Brian Kendig - Self-photographed, CC BY-SA 3.0

Are elevated guideways really an issue?

Some people claim that elevated structures are ugly or unsightly. The iconic Disney monorail would offer counter-evidence. Some people actually miss the monorail in this picture.

Disney's Contemporary is an example of a building-integrated transit system. Architects will have exciting new ways to integrate transportation and living space.

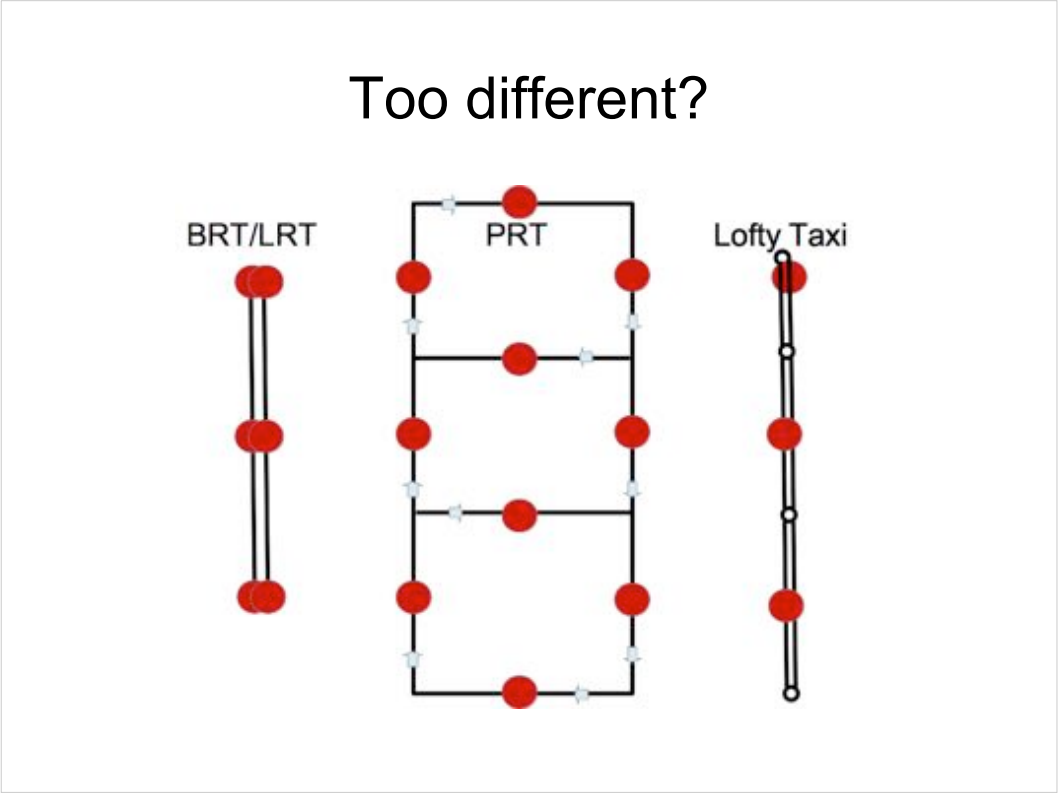
Context matters as well for elevated structures. Since Lofty Taxi is to be installed where population density is high, this means that buildings also go vertical. Some high-rises are beautiful, others not so much. There are interesting possibilities to make guideway architecturally pleasing, various pillars and support structures, perhaps more akin to bridge design.

Too elevated?

2013 bus-train crash in Ottawa

By: Transportation Safety Board of Canada

Grade separation has its advantages. This recent crash between a train and transit bus in Ottawa at a level crossing was particularly ugly and tragic.



Is it too different?

Lofty Taxi can be classic PRT layout where single-direction guideways cover the maximum area possible.

Because LT has a tight turn radius, roundabouts can be used at intersections. This allows layouts that start the same way as LRT or BRT layouts do – in a line. This means that defined ROW can be used directly without the need to redefine the study area or intended route.

Too different?

Lofty Taxi roundabout

Roundabouts allow stations to be placed on one side or the other of a dual-direction guideway instead of having them on both sides. The vehicles move so riders don't have to.

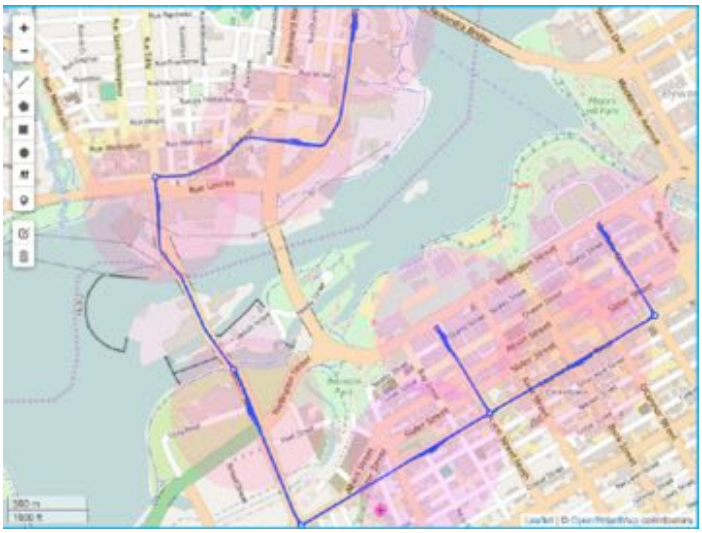
Too different?

Lofty Taxi u-turn

Another feature tight radius allows is u-turns so that spurs can be extended and make the layout flexible.

Too different?

Lofty Taxi layout for Ottawa



This is a suggested layout for an Ottawa to Gatineau “loop”. It would serve some of the highest population density areas and connect mass transit systems on either side of the river. Note that it is actually C-shaped avoiding the already overburdened Alexandra bridge...

Too different?

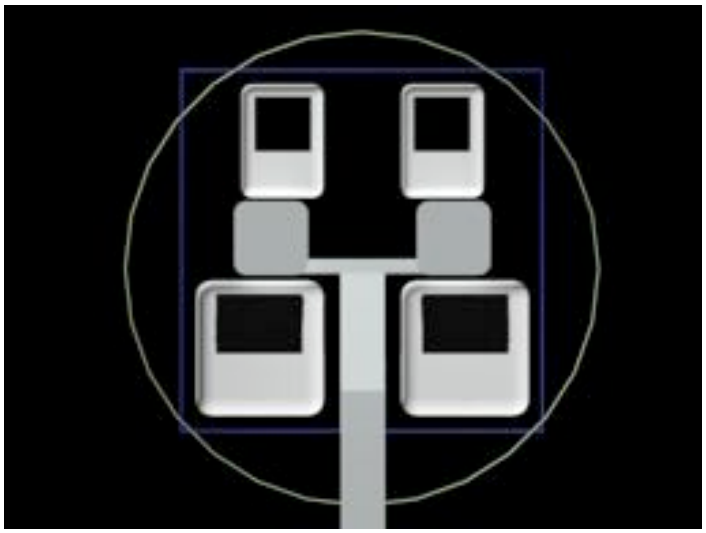
Alexandra Bridge

By Ccyyrree - Own work, CC0

...which has an additional road lane tacked onto one side and a walkway tacked on to the other.

Too different?

LT compact vehicle arrangement



One of the design goals is to run 4 LT lanes inside roadway space, so less than 16 ft (5 m) high and as narrow as possible, to allow building in transitway/busways or even in train tunnels where two lines could mean up to 40,000 pph.

Too inflexible?

Is it too inflexible?

Fixed infrastructure systems are both criticized and praised for their inflexibility. Businesses, offices and housing built around the system are assured a great level of permanence.

A PRT network is also meant to expand as a city grows and its population density increases.

Too inflexible?

ULD sized cargo

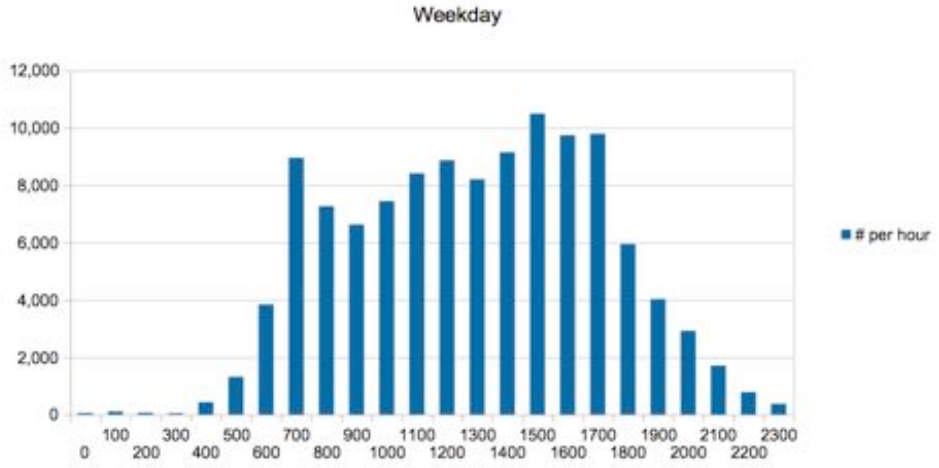
By Dtom - Own work, Public Domain

Another aspect of inflexibility is the type of vehicles that are used on a guideway. Lofty Taxi aims to carry not just people, but cargo as well. Pallets, skids and aircraft ULD. Carrying other types of vehicles, like small EV carriers can be pursued at a later time.

The ability to deliver pallets directly from producer to small merchant, vending machine or even consumer is a paradigm shift. Truck loads will no longer be the unit of commerce.

Robotic delivery vehicles will help enable this shift and Lofty Taxi can have a significant role for transportation in and between high density areas.

Too expensive?



Data from: http://www.fhwa.dot.gov/policy/2013cpr/chap1.htm

Is it too expensive?

It has been claimed that PRT is too expensive for low population density areas and too low capacity for high population density areas.

There are ways to address this issue, one is to make vehicles as small and lightweight as possible and guideway as inexpensive and light as possible. Another is the way LT does it, by delivering high capacity at the lowest possible cost. PRT, being similar to a taxi service tends to have a fuller distribution of trips than the twin peaks of LRT or BRT systems. Plus LT can move cargo at off peak times.

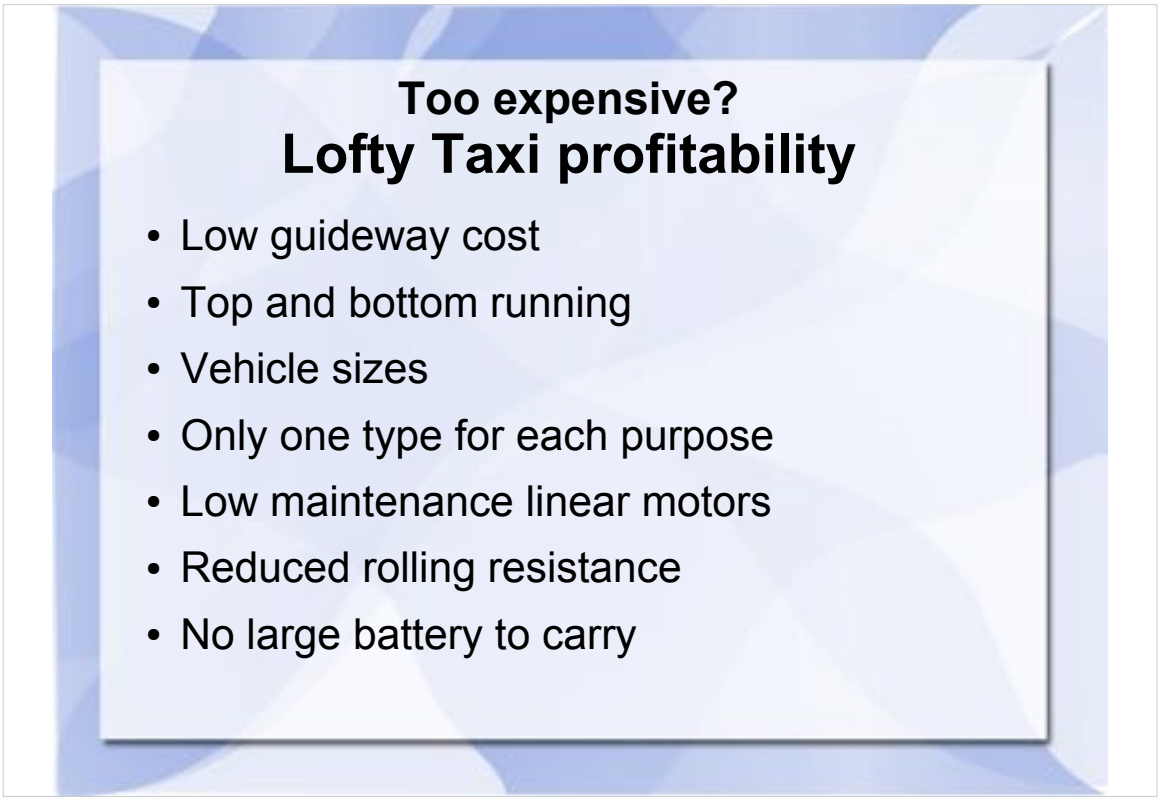
Too expensive?

Los Angeles LRT

By The Port of Authority (talk) - Own work (Original text: self-made), Public Domain

PRT leverages automated “driving” to bring Mass Transit economies of scale to Personal Transportation. The same trend where larger articulated or double-deck buses or LRT trains, like this one, require less drivers, works for PRT requiring only a few whole system monitors for safety and security.

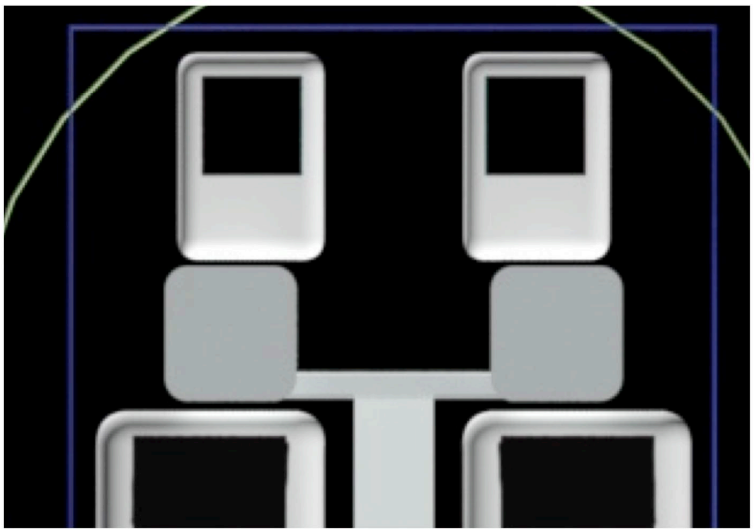
We have already looked at the high-capacity aspect of Lofty Taxi, now lets look at how it can be profitable:



Guideway cost is minimized by using dual-direction guideway. Estimates usually put dual-direction over single-direction at 75% per guideway. So this reduces the cost of the guideway portion, which usually represents 50% of PRT cost, significantly.

Too expensive?

Lofty Taxi guideway structure



Lofty Taxi uses I-beams with cross-bracing to reduce guideway cost and provide an emergency walkway.

Running top and bottom on a single-beam also reduces the cost of infrastructure.

Having purpose-sized vehicles, two person wide for those with larger loads, mobility devices, prams or bicycles and narrower tandem vehicles for that large fraction of patrons who travel alone, reduces the weight that needs to be moved, reduces the materials needed to build and aerodynamic drag for the fleet.

Keeping large vehicles on the bottom and smaller vehicles on top delineates versions where, for example CabinTaxi had top and bottom-running vehicles of all sizes, so only one version per type needs to exist.

Steel wheels on steel rail reduces rolling resistance and energy used and also increases scheduled maintenance intervals.

Lofty Taxi is expected to be profitable based on operation and maintenance cost and including capital amortization.

Too good to pass up

For **cities with high-capacity** transit requirements and
for **intercity high-speed** land based travel - because it features:

- Quick transit
- Direct to destination, no transfers, little to no waiting convenience
- Personal travel
- Road lanes remaining functional and traffic flowing freely in cities
- Easy traversing beneath guideways and flexible intercity routing
- Cargo transportation
- Safety
- and Profitability

Lofty Taxi