



Hyperloop on the Northeast Corridor

A proposal for the first U.S. hyperloop:
Boston, New York, Philadelphia, Washington, DC

Supporting document for Drexel's SpaceX Hyperloop Pod Competition entry

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1. Executive summary

The first real hyperloop should run Boston to New York to Philadelphia to Washington, DC. No other corridor in the US has this much demand packed into this short a distance, and demand is the only thing that can pay for building hundreds of miles of tube.

- **Where:** The Northeast Corridor (NEC). It already carries over 820,000 rail trips a day, sits next to the biggest container port on the East Coast, and is home to more than 51 million people.
- **Why now:** The corridor is maxed out. Cars still carry about 78% of trips between its big cities, the fastest train averages well under 100 mph, and the official plans to fix the rail line cost \$24 billion for the Hudson tunnels alone and over \$100 billion for the full upgrade.
- **How it's paid for:** A league model borrowed from the NFL. The public funds stations and the tube right-of-way, the way cities fund stadiums. Private operators own and run service at each hub, like teams. A central league office sets shared rules, safety standards, and revenue sharing.
- **What's hard:** Four different right-of-way owners, eight states plus DC, no federal safety rules written for hyperloop yet, and real safety questions about putting people in a near-vacuum tube.
- **How it grows:** Prove the economics on a Philadelphia to New York line first, then build out the full NEC, then add spokes to other big hubs only after Phase 1 shows it can pay for itself.
- **Our tech angle:** Drexel's pod uses air bearings, the levitation method from Hyperloop Alpha, while many teams in this competition are going with magnets. Air bearings keep the tube simple and cheap, and the tube is most of the cost.

The numbers at a glance

Metric	Today (2016)	With hyperloop (our estimate)
New York to Washington	2 hr 45 min on the fastest Acela	About 30 min nonstop
New York to Boston	3 hr 30 min on the fastest Acela	About 30 min nonstop
Boston to Washington	About 6 hr 30 min by train	Under 1 hr nonstop
Build cost, full corridor	Not built	About \$40B (planning assumption)
Riders per year	11.9M on Amtrak NEC trains (FY16)	About 23M needed to break even at a \$100 margin

SpaceX asked teams to design a pod. We designed a pod, but we also asked where the first line should go and who pays for it, because we think that's what decides whether hyperloop ever gets built. The rest of this document lays out that case in detail, including the parts that could go wrong.

2. Who we are

Drexel Hyperloop is a team of roughly 70 students from engineering, computer science, finance, and marketing at Drexel University in Philadelphia. We started in 2015 out of a College of Engineering senior design project and have been working toward the SpaceX Hyperloop Pod Competition since it was announced that June.

When	What
Aug 2013	Hyperloop Alpha published: pods at about 760 mph in low-pressure tubes, LA to San Francisco, estimated at about \$6 billion
Jun 2015	SpaceX announces the Hyperloop Pod Competition
Jan 2016	We present our full design at Design Weekend at Texas A&M, alongside 120+ teams
Early 2016	Drexel is one of about 31 teams selected to build a pod
2016	Building and fundraising; shipping the pod to California alone is budgeted at about \$40,000

How the team works

The pod is split into about ten engineering subsystems that roll up into one vehicle: structure, aerodynamics, levitation, braking, controls, software, and so on. Each subsystem is run by students whose senior design project covers that piece. A business team handles sponsorship, fundraising, budgeting, outreach, and the bigger question this paper tries to answer: what would it take to turn a pod into a real transportation system.

We are backed by local engineering and design firms, including New Way Air Bearings, Delphinus Engineering, and M2VP, plus Drexel itself. Most teams picked one subsystem. We took on the whole pod, and we also designed a passenger station. That habit of thinking about the full system is why this proposal exists.

How we think about the critics

We take the skeptics seriously. Transportation experts said Alpha's \$6 billion number was way too low, and California's high-speed rail chief guessed the tubes alone could cost \$15 to \$20 billion. Every cost number in this plan assumes something much closer to the critics' view than to Alpha's.

3. The problem: Northeast travel is stuck

The Northeast is the most important travel market in the country, and it is running out of room. Trains are slow by world standards, highways are jammed, and the plans to fix the rail line cost more than most states can raise.

Most people still drive

The Northeast Corridor Commission's 2015 intercity travel study found that cars carry about 78% of trips between the corridor's big air markets. Among trips on commercial carriers, rail carries 41%, buses 34%, and planes 25%. In the head-to-head fight between trains and planes, Amtrak already wins with about 63%. That tells us two things: people will choose ground transport when it's fast enough, and the biggest pool of riders to win over is drivers, not flyers.

Cars carry almost 4 out of 5 trips between the corridor's big cities

Share of trips between major NEC air markets, from the NEC Commission's 2015 intercity travel study

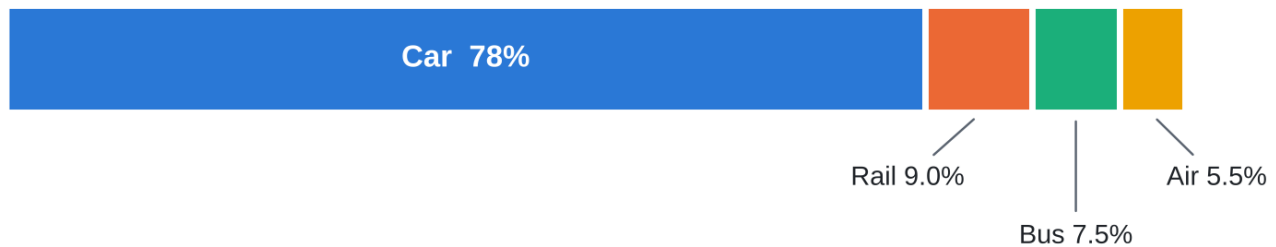


Figure 1. Mode share of trips between the NEC's major air markets. Rail, bus, and air split the remaining 22% at 41%, 34%, and 25%. Source: Northeast Corridor Commission intercity travel study (2015).

The trains aren't fast

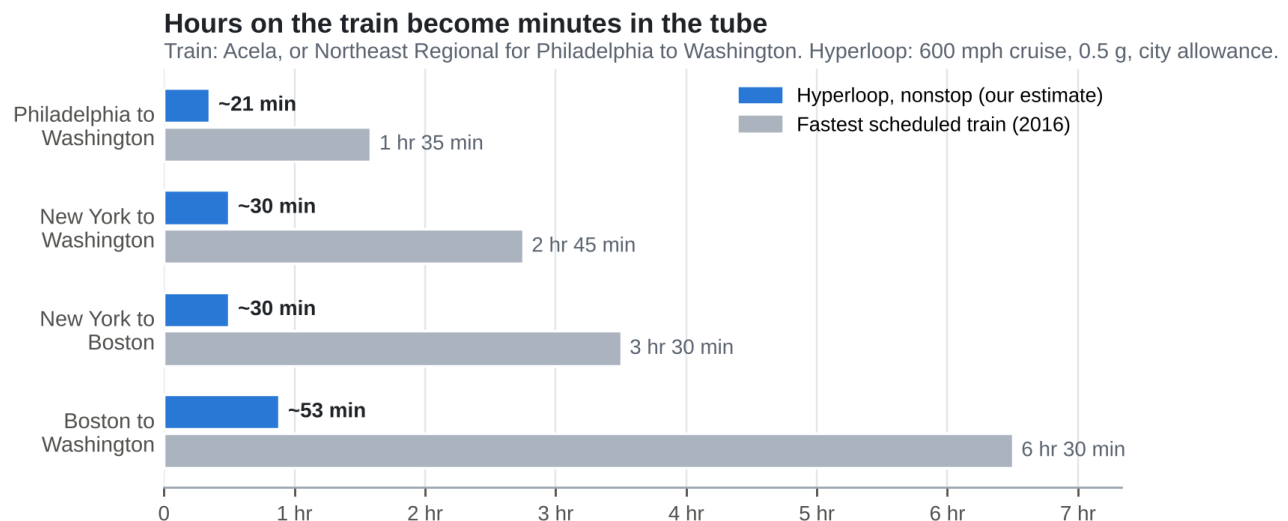


Figure 2. Fastest scheduled train times in 2016 vs. our nonstop hyperloop estimates. Train trips average about 66 to 86 mph including stops. Hyperloop times assume a 600 mph cruise, 0.5 g acceleration, and about 6 minutes of slower running in cities.

Acela is the only high-speed train in the US, but old curves, bridges, and tunnels hold it to an average of about 66 to 82 mph. Amtrak announced in 2016 that it will spend nearly \$2.5 billion on new Acela trainsets and upgrades, which helps, but new trains can't fix a 100-year-old right-of-way.

The fixes are huge

- **Gateway:** Amtrak's plan to add new Hudson River tunnels and double capacity between Newark and New York could cost up to \$23.9 billion, including \$7.7 billion just for the tunnels.
- **NEC FUTURE:** The Federal Railroad Administration's long-term plan for the corridor puts its preferred upgrade at \$113 to \$118 billion (2014 dollars). Even then, the fastest trains would only save about 30 minutes between Washington and New York and about 45 minutes between New York and Boston.

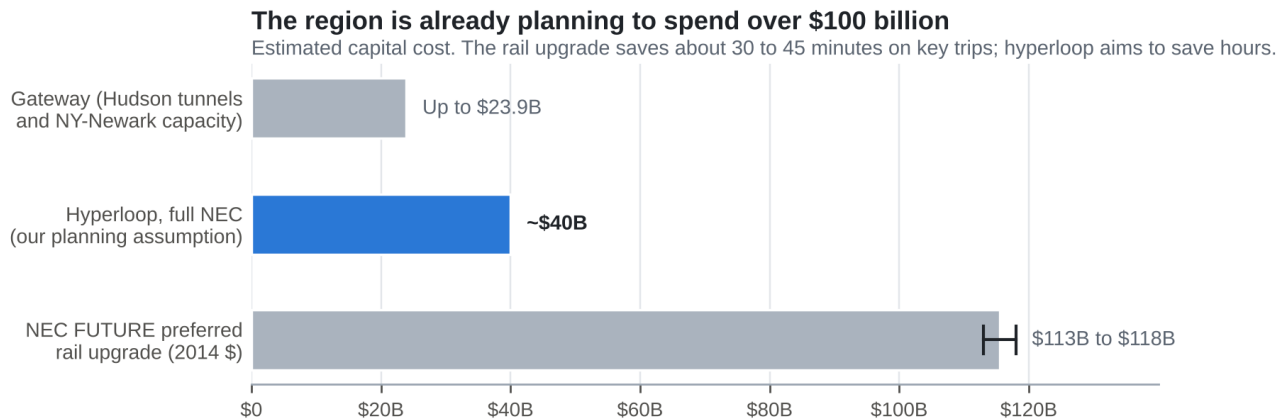


Figure 3. Estimated capital costs. Gateway: Amtrak, Jan 2016. NEC FUTURE: FRA preferred alternative, 2014 dollars. Hyperloop: our planning assumption, not an engineering estimate.

Our argument is simple. If the region is going to spend \$100+ billion on transportation anyway, it should at least study a technology that could cut those trips from hours to minutes instead of shaving off half an hour.

4. Our pod: air bearings, like the original paper

Drexel's pod floats on air bearings, the same idea Musk proposed in Hyperloop Alpha. Many teams in this competition, including MIT's Best Overall Design winner, are using magnetic levitation instead. We think air is the better bet for a cheap, buildable tube.

What Hyperloop Alpha says

Alpha doesn't use magnets to float the pod. It uses air bearings, which work like an air hockey table, plus a compressor fan on the nose that moves high-pressure air from the front of the pod to the back. Some of that air feeds the bearings. The pod makes its own air cushion, so the tube can stay a plain, low-cost steel pipe.

Alpha design spec	Value
Passengers per pod	28
Departures	Every 2 min on average, every 30 sec at peak
Throughput	About 840 passengers per hour per direction

Alpha design spec	Value
Tube inside diameter	About 7 ft 4 in (2.23 m) for passenger-only tubes
Tube pressure	About 100 Pa, roughly 1/1000 of normal air pressure
Top speed	760 mph
Comfort limit	0.5 g for passengers on the route, 1 g max at the accelerators
Cost per pod	About \$1.35 million
Stations	About \$125 million each

What we built

Our pod uses round, puck-shaped air bearing nodes under a dynamic floor, a layout no other team is using. Our sponsor New Way Air Bearings donated graphite air bearing parts, including one rated for about 360 pounds. For braking, we designed flaps that open up and build pressure in front of the pod, like pushing a syringe plunger. Because they use the air already in the tube, the flaps work as a backup brake even if the pod loses power.

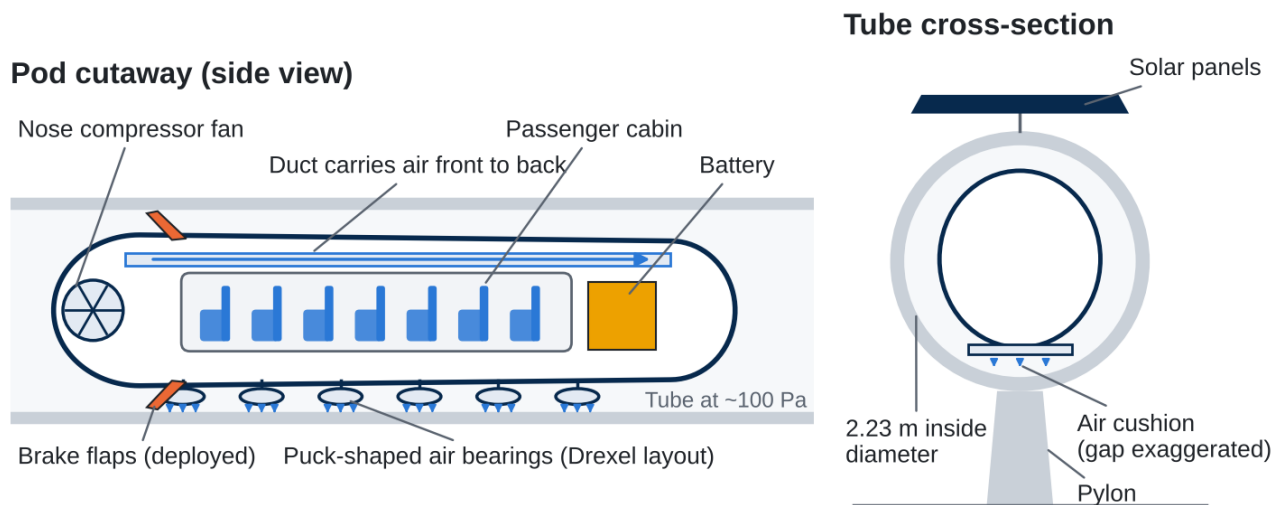


Figure 4. Concept illustration, not to scale. Pod layout follows Hyperloop Alpha (nose compressor, air bearings, low-pressure steel tube with solar panels on top) with Drexel's puck-shaped bearing nodes and air-pressure brake flaps.

Air bearings vs. magnets

	Air bearings (Alpha, Drexel)	Magnetic levitation (MIT and others)
Where the cost lives	In the pod (compressor, bearings, battery)	In the track (conductive rail or magnets the whole length)
Tube	Simple steel pipe	Pipe plus an engineered guideway
Main risk	Power needed to make an air cushion in thin air	More expensive, more complex track per mile
Ride gap	Very small, tight tolerances	Larger gap, more forgiving
What it means at scale	Cost scales with the number of pods	Cost scales with the number of miles

Why this matters for the business case. On a 450-mile corridor, the tube is most of the cost, and you build it once. Pods are a smaller, repeatable cost that can keep getting better. Air bearings put the hard engineering into the pod, where it can be improved, instead of into hundreds of miles of track.

The honest unknown. Nobody has measured how much energy it takes to run the compressor and bearings in a near-vacuum over hundreds of miles. Tight bearing gaps also mean the tube has to be built and maintained to very precise tolerances. Those are the two things a Phase 1 test line has to measure before anyone commits to air bearings for a full corridor. If the numbers come back bad, the funding model and route in this paper still work with magnetic levitation; only the cost split between pods and track changes.

5. Why the Northeast Corridor wins on unit economics

A hyperloop is almost all fixed cost. You pay for the tube whether one person rides or a million do, so the best first route is the one with the most riders per mile. That's the Northeast Corridor, not LA to San Francisco.

The demand is already there

- The NEC main line runs 457 miles from Washington, DC to Boston.
- It carries over 820,000 trips a day on more than 2,100 trains, about 780,000 on eight commuter railroads and 43,000 on Amtrak.
- Amtrak carried a record 11.9 million passengers on its NEC trains in fiscal 2016, out of 31.3 million systemwide.
- The NEC region is home to more than 51 million people and four of the ten largest US metro areas.
- A study for the Northeast Corridor Commission found that losing the NEC for a single day would cost the country nearly \$100 million.

The cities are the right distance apart. Boston to New York, New York to Philadelphia, and Philadelphia to DC are each short enough that flying is a hassle and long enough that driving or Amtrak takes hours. That middle distance is exactly where a 600+ mph pod beats everything else door to door.

Break-even math

These are our planning assumptions, not a forecast. The point is to show what has to be true for the system to pay for itself.

Input	Assumption	Why
Build cost, full NEC	\$40 billion	Far above Alpha's ~\$17M per mile, closer to critics' numbers once tunnels and city stations are included
Financing	5% over 40 years	Typical for long-life public infrastructure
Yearly capital cost	about \$2.3 billion	Standard loan payment on the above
Margin per ride	\$100 after operating costs	Premium fare, similar to Acela pricing
Rides needed per year	about 23 million	\$2.3B divided by \$100

What if we're wrong? The table below shows how many rides a year the system needs under different build costs and margins. Even in the best case it needs more riders than Amtrak's whole NEC business carries today.

Build cost (yearly payment)	\$75 margin per ride	\$100 margin per ride	\$125 margin per ride
\$30B (\$1.75B / yr)	23.3M rides	17.5M rides	14.0M rides
\$40B (\$2.33B / yr)	31.1M rides	23.3M rides	18.6M rides
\$60B (\$3.50B / yr)	46.6M rides	35.0M rides	28.0M rides

Rides needed per year to cover capital cost at 5% over 40 years. Amtrak's NEC carried 11.9 million riders in fiscal 2016.

Where the riders come from

23 million riders a year is about twice Amtrak's entire NEC ridership. So hyperloop can't live off Amtrak riders alone. It has to pull from three pools at once:

- 1 Drivers.** Cars carry about 78% of trips between the big NEC cities. Winning even a small slice of I-95 traffic is worth more than taking every Acela rider.
- 2 Air shuttle flyers.** Boston, New York, and Washington are connected by hourly shuttles. A 30-minute pod ride from downtown to downtown beats a 1-hour flight plus airport time.
- 3 Freight.** Off-peak and overnight capacity sold to shippers lowers the number of passengers the system needs (see Section 8).

Can the tube even carry that many people?

This is the question most hyperloop pitches skip. Alpha's design moves about 840 people per hour per direction, which works out to about 5.5 million seats a year each way if it ran 18 hours a day. That's not enough.

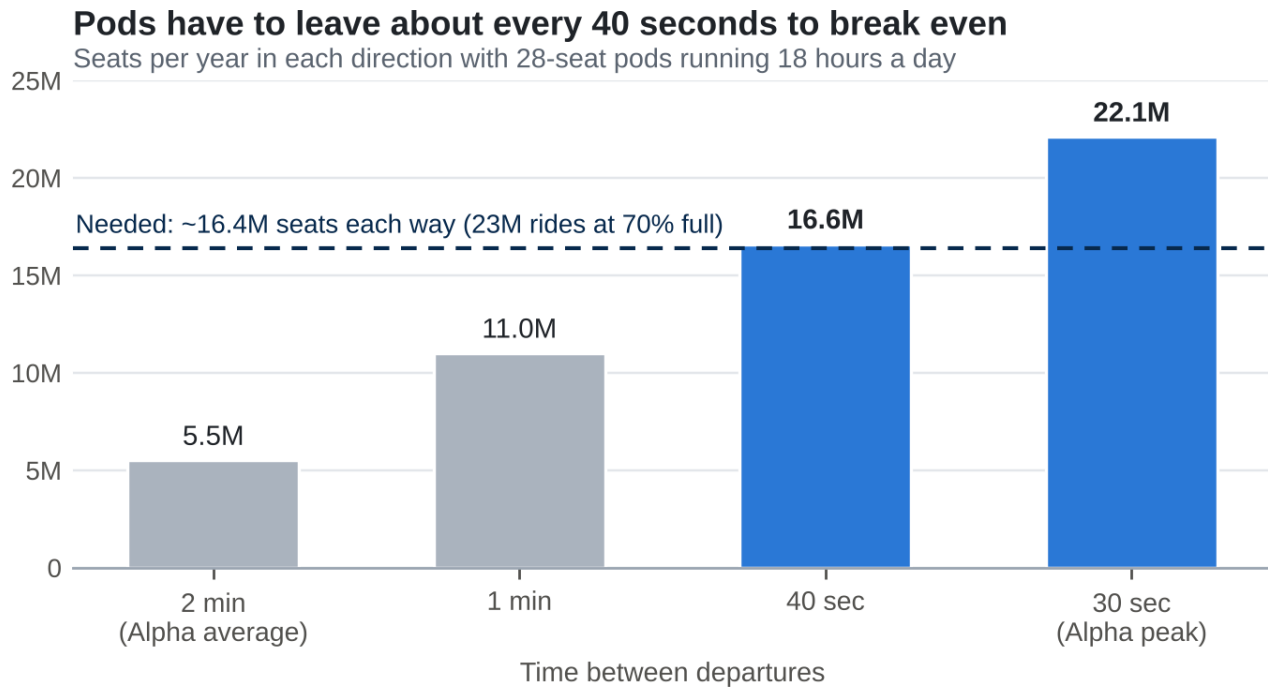


Figure 5. Seats per year in each direction at different departure intervals, assuming 28-seat pods running 18 hours a day. The dashed line is the capacity our 23M-ride break-even target needs at 70% full.

To hit 23 million rides at a realistic 70% load factor, pods need to leave about every 40 seconds all day, which is close to Alpha's peak rate. That pushes us toward two design choices: bigger pods (40+ seats) or a second tube pair on the busiest segment, New York to Philadelphia. Either way, capacity has to be designed in from the start, not added later.

A rough revenue mix

Source	Volume	Contribution to the \$2.3B yearly payment
Passengers	18M rides at \$100 margin	\$1.8B
Freight	Overnight and off-peak capacity	\$0.5B needed
Station retail and leases	Five city hubs	Upside, not counted

Illustrative only. The point: freight doesn't have to be huge, it just has to cover the gap so the passenger target drops to a number the corridor can realistically deliver.

6. Route and stations

The tube follows the corridor people already travel, with stations next to the existing train stations so riders can transfer to local transit.

One tube, five city hubs, under an hour end to end

Proposed alignment follows the existing Northeast Corridor. Times are our estimates.



Figure 6. Proposed Phase 1 and Phase 2 alignment along the existing Northeast Corridor, with passenger stations next to existing train stations and freight bays near Port Newark/Elizabeth and the Philadelphia Navy Yard. Schematic; not a surveyed route.

Segment	Route miles	Est. hyperloop time	Proposed stations
Boston to New York	231	About 30 min	Boston South Station area; Manhattan West Side near Penn Station
New York to Philadelphia	91	About 16 min	Penn Station area; Philadelphia 30th Street Station
Philadelphia to Baltimore	96	About 17 min	30th Street Station; Baltimore Penn Station
Baltimore to Washington	40	About 11 min	Baltimore Penn Station; Washington Union Station
Full corridor, nonstop	458	Under 1 hr	Boston to Washington

Times assume 600 mph cruise, 0.5 g acceleration, and about 6 extra minutes per trip for slower running in city tunnels. Route miles follow the existing NEC.

Why small pods change the schedule

Trains stop at every station on their line. Pods don't have to. Because each pod carries about 28 to 40 people, a station can send pods straight to whichever city has the most demand. A Boston rider headed to DC never stops in New York; the pod switches through it on a bypass track. That's how a 458-mile trip gets under an hour.

Station design

Our team designed a passenger station as part of our competition work, and the same ideas scale to a corridor hub. Each station would include:

- **Airlock loading bays** where pods dock, seal, and equalize pressure before doors open, so the main tube never loses vacuum.
- **A pod yard** with spare pods charging and waiting, so departures can match demand minute by minute.
- **A freight bay** on a separate level with its own loading docks, used most heavily overnight.
- **Direct connections** to Amtrak, commuter rail, subway, and buses, since most riders start and end their trip somewhere else.
- **Airport-style screening** that is fast enough not to erase the time savings.
- **Leasable retail and office space**, which supports the hub operator's business (see Section 9).

Station concept: pods load off the main line, riders transfer straight to local transit

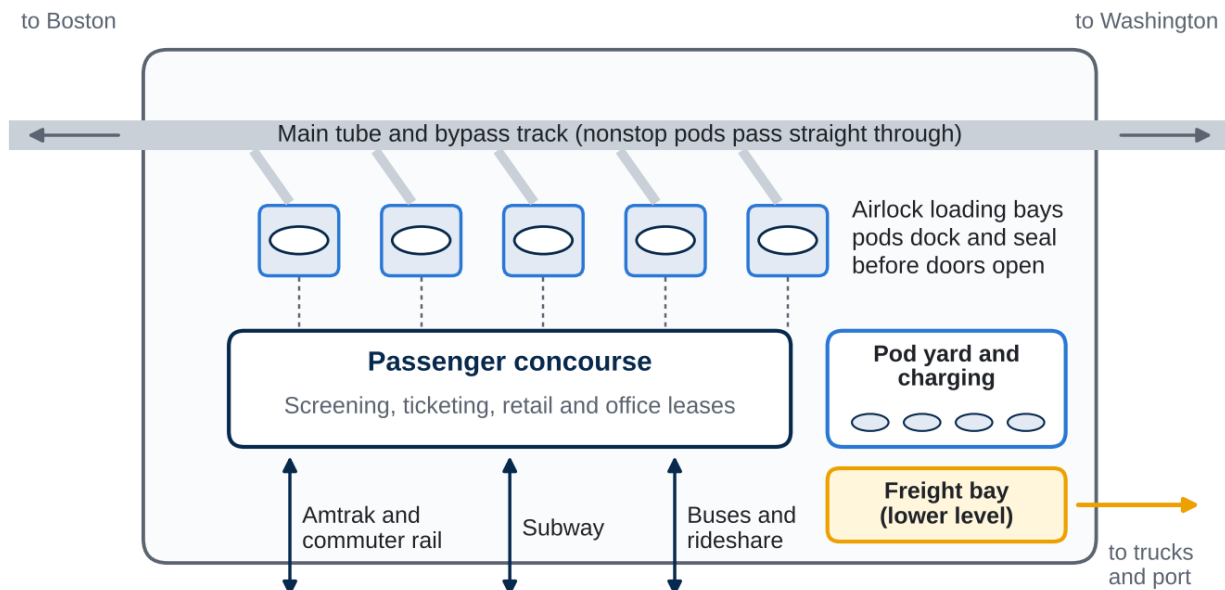


Figure 7. Station concept, plan view, not to scale. Pods leave the main tube on side branches to sealed loading bays, so nonstop pods can pass straight through on the bypass.

Philadelphia's station at 30th Street would sit right next to Drexel's campus, which also makes it a natural home for a research and testing partnership with the university.

7. Energy and environment

Alpha claims a hyperloop can power itself. It estimates the LA to San Francisco system would need about 21 MW on average, while solar panels on top of the tube would make about 57 MW on average, with batteries covering nights and cloudy days.

We think that claim needs a reality check for the Northeast. The NEC gets less sun than California, the tube would run underground in cities, and our air-bearing design adds compressor load that has never been measured at scale. Our working assumption is that the line buys most of its power from the grid, with solar as a bonus. Even so, an electric system that pulls riders out of cars and short flights would cut emissions on the busiest travel market in the country.

8. Freight, logistics and shipping

Freight is how the tube earns money at 2 a.m. Passengers fill rush hours; cargo fills everything else, which spreads the fixed cost over a lot more trips.

- The Port of New York and New Jersey, the largest cargo gateway on the East Coast, handled about 6.25 million TEUs (twenty-foot container units) in 2016.
- Its on-dock rail moved about 540,000 TEUs in 2016, up 3.4%, which shows shippers already want to get boxes off trucks and inland faster.

What fits in a pod

Full 40-foot containers are a stretch for a passenger-sized tube. The realistic early market is high-value, time-sensitive freight: e-commerce parcels, pharmaceuticals, medical supplies, and overnight shipments between NYC, Philly, and DC distribution centers. That's freight that moves by truck or air today.

How freight would run

Time window	What runs	Why
Rush hours	Passengers only	Every slot is worth more as a seat
Midday and evening	Mixed, with some freight pods	Fills gaps between passenger peaks
Overnight (about 6 hr)	Mostly freight	Next-morning delivery anywhere on the corridor

Design rule: every station gets a freight bay from day one, near port and warehouse districts like Port Newark and the Philadelphia Navy Yard, instead of adding one later.

9. Ownership and funding: the NFL league model

We propose running hyperloop like the NFL: taxpayers fund the big fixed assets, private owners run each local franchise, and a central league office keeps everyone on the same rules and splits shared revenue.

How the NFL works

The NFL's league office was a tax-exempt 501(c)(6) trade association from 1942 until it gave up that status for the 2015 fiscal year. The 32 teams have always been private, taxable businesses. Meanwhile, cities and states have put billions of public dollars into stadiums. So the model is: public money builds the venue, private owners run the team, and a league office (a nonprofit until last year) coordinates.

How that maps to hyperloop

NFL	Hyperloop League	Who pays / owns
Stadium	Stations and tube right-of-way	Public: federal, state, and city funds, municipal bonds
Team	Hub operator (e.g. Hyperloop Philadelphia)	Private: owns pods, runs service and retail at its hub
League office	Nonprofit Hyperloop League authority	Funded by member fees; sets safety, ticketing, and scheduling standards
TV and revenue sharing	Shared track-access fees and through-ticket revenue	Split across operators so smaller hubs survive
Expansion teams	New cities joining in Phase 3 and 4	New hub operators buy a franchise; their city funds its station

Where the public money would come from

Source	What it could pay for
Federal grants (e.g. TIGER)	Early studies and the Phase 1 environmental review
Federal loans (RRIF, TIFIA)	Long-term, low-rate debt for the tube and stations
FAST Act passenger rail programs	A possible path if hyperloop is treated as intercity passenger rail
State and city bonds	Each city's station, the way cities bond for stadiums
Value capture around stations	Higher property values near hubs help repay station debt, like the 7 train extension to Hudson Yards

What the private side brings

- Pods, maintenance, and day-to-day operations at each hub.
- Station retail, advertising, and freight contracts.
- Technology risk: if a better pod comes along, operators upgrade their fleets without new public money.

Why this structure. No single private company can carry a \$40 billion tube by itself, and Alpha never really answered who would pay. Public agencies are good at long-life infrastructure and bad at running fast-moving technology. This model gives each side the part it's good at. Each city also gets a hub it owns and is proud of, the same way fans feel about their team.

The fair criticism. Most economists think stadium subsidies are a bad deal for taxpayers. To avoid that, our version has guardrails:

- 1 Operators pay track-access fees back into the public fund on every trip.
- 2 The public gets a share of operator profits above a set return.
- 3 Stations are real transit hubs open to buses and local rail, not private venues.
- 4 Operators that miss safety or service standards can lose their franchise, the way the league can discipline a team.

10. Policy, zoning and right-of-way challenges

The NEC's biggest strength, dense cities, is also its biggest problem: there's almost no open land, and every mile crosses several governments.

- **Too many owners.** The NEC main line runs through eight states plus DC and has four different right-of-way owners, shared by Amtrak, eight commuter railroads, and freight railroads. Any new tube needs deals with most of them.
- **No rulebook.** There's no federal safety framework written for hyperloop, and it isn't clear whether it would be regulated like a railroad, an aircraft, or something new. Until that's settled, investors can't price the regulatory risk.
- **Environmental review takes years.** Any federally funded line needs a full federal environmental review, plus extra permits wherever tubes cross rivers and wetlands, and the NEC crosses a lot of them.
- **Local zoning and land.** Elevated pylons through suburbs in New Jersey, Connecticut, and Maryland will face neighborhood pushback. Downtown stations need some of the most expensive land in the country.
- **Competing for the same dollars.** The NEC already has a huge repair backlog and Gateway's \$23.9 billion price tag. Politicians will ask why fund an unproven tube instead of fixing tunnels that exist today.

How we'd handle it

- 1 Follow existing highway and rail right-of-way (I-95, the NJ Turnpike, the Baltimore-Washington Parkway, Amtrak's corridor) to avoid new land takings, the same approach Alpha proposed with I-5.
- 2 Go underground in city centers and elevated in between, matching what local zoning will accept.
- 3 Ask Congress to name one lead federal agency and create a fast-track permitting path for the Phase 1 test line.
- 4 Use an interstate compact, like the one that created the Port Authority of New York and New Jersey, so states negotiate once instead of one at a time.
- 5 Do the environmental review in two tiers, the way FRA's NEC FUTURE study did: one corridor-wide review of the concept, then detailed reviews segment by segment, so Phase 1 doesn't wait on Boston.

Who would regulate it? (open question)

Option	Upside	Downside
Treat it like a railroad	Existing safety process; clear funding programs	Rail rules weren't written for sealed pods in a vacuum
Treat it like aviation	Aviation rules handle pressurized cabins	Built around airplanes and airports, not ground lines
Create a new category	Rules that fit the technology	Takes longest; needs Congress

Our recommendation is a new category with rail as the starting template, since hyperloop is still a fixed-guideway ground system.

11. Safety concerns and mitigation

People will only ride if they trust it, and one bad accident would end the industry. Safety has to be designed in, not added later.

Risk	Why it matters	How we'd reduce it
Loss of tube pressure	A breach lets air rush in and slow or damage pods	Sectioned tube with valves that isolate a leak, like bulkheads on a ship
Pod depressurization	Passengers are in a sealed cabin inside a near-vacuum	Aircraft-style cabin pressure and oxygen masks
Getting people out	You can't just open a door in a tube	Emergency exits and airlocks at set intervals; pods able to coast to the next exit
Braking failure	At 600+ mph, stopping distance is huge	Redundant brakes; our air-pressure flaps as a backup that works without power
Earthquakes, heat, ground shifts	Tubes expand, contract, and move	Expansion joints and flexible pylon mounts, as Alpha proposed

Risk	Why it matters	How we'd reduce it
Rider comfort	Fast acceleration and curves can make people sick	Hold acceleration to 0.5 g and keep the route as straight as possible
Fire	Smoke has nowhere to go in a sealed tube	Fire-resistant materials, onboard suppression, and pods that keep moving to the next station
Security	Tubes and stations are a target	Airport-style screening at stations; monitored tube sections

A breach scenario, step by step

- 1 Sensors detect a pressure rise in one tube section.
- 2 Valves on both sides of that section close, so the rest of the tube stays at low pressure.
- 3 Pods heading toward the section brake, using their own brakes plus the air-pressure flaps.
- 4 Pods already inside the section are slowed by the rising air pressure and stop at the nearest emergency exit.
- 5 All other pods on the line hold at stations until the section is cleared.

The league office would own safety standards for every operator, the same way one rulebook covers every NFL team. That avoids a race to the bottom between hubs.

12. Competing projects and plans (2016)

We are not the only people trying to fix Northeast travel. Here's what else is in motion and how a hyperloop fits next to it.

Project	What it is	Status in 2016	How hyperloop compares
Acela upgrades	New trainsets and upgrades on the existing line	Amtrak committed nearly \$2.5B	Faster trains on old tracks; still hours, not minutes
Gateway	New Hudson River tunnels and capacity	Estimated up to \$23.9B	Needed either way; hyperloop doesn't replace commuter capacity
NEC FUTURE	FRA's long-term corridor plan	Preferred plan \$113 to \$118B (2014 \$)	Saves 30 to 45 min on key trips for 3x the cost of our estimate
Northeast Maglev	Japanese superconducting maglev, Baltimore to DC first	FRA awarded \$27.8M for engineering and environmental review	Proven tech at about 314 mph; hyperloop aims for twice that
Hyperloop One	Private hyperloop company	Raised \$80M in May 2016; ran an open-air propulsion test in Nevada	A potential tech partner or operator under our league model

The takeaway: the region is already planning to spend well over \$100 billion. Maglev shows that a new technology can get federal study money on this corridor. Hyperloop companies are raising real money but still don't have a route or an owner. Our plan gives them both.

13. Phase 1 in detail: Philadelphia to New York

Phase 1 is a 91-mile line between Philadelphia and New York. It's short enough to build first, busy enough to matter, and it passes right by the Port of New York and New Jersey for freight.

Why this segment

- It connects the two biggest metros on the corridor's southern half, with New Jersey's dense commuter market in between.
- The NJ Turnpike and Amtrak's line give two possible right-of-way paths through one state, which means one state government to work with instead of several.
- Freight from Port Newark and Elizabeth can fill overnight capacity from day one.
- Philadelphia's 30th Street Station is next to Drexel, giving the project a university research partner on site.

How Phase 1 would roll out

Stage	What happens	What it proves
1a. Studies	Route study, ridership survey, first-tier environmental review	Demand and route are real
1b. Test section	A few miles of full-size tube along the chosen route	Air-bearing energy use, tube tolerances, safety systems
1c. Freight first	Run cargo pods on the finished line before passengers	Reliability and revenue with no riders at risk
1d. Passenger service	Open to riders after safety certification	Ridership, fares, and operating cost

Rough cost. At our \$40 billion corridor assumption (about \$88 million per mile), the 91-mile Phase 1 line would cost about \$8 billion. We'd plan for a range of \$5 to \$10 billion until real engineering is done.

What Phase 1 has to show

Measure	Why it matters
Energy per pod-mile	Decides whether air bearings work at scale or we switch to magnets
Build cost per mile	Tells us if the \$40B corridor estimate holds
Daily riders and fares	Tests the 23M-ride break-even target on a smaller scale
Freight revenue	Tests whether cargo can cover the gap
Safety record and certification	Nothing expands without it

14. Phased expansion roadmap

We start with one short, high-demand segment and only expand once the numbers prove out. Selling a whole national system before one segment works is how big transit projects stall; this plan does the opposite.

Each phase must pay for itself before the next one starts

Phase 1: Philadelphia to New York test line

About 90 miles along existing right-of-way, carrying passengers by day and freight overnight.
Goal: measure real cost per trip, energy use per pod, and ridership.



Gate: fares plus freight cover operating costs, and regulators approve the safety case

Phase 2: Full Northeast Corridor, Boston to DC

Extend north to Boston and south through Baltimore to Washington, DC.
Hub operators take over each city; the league office sets shared rules and revenue sharing.



Gate: roughly 23M+ rides a year, with track fees paying back the public build cost

Phase 3: Spokes to major inland hubs

Branch west to Pittsburgh and Chicago, and south to Richmond, Charlotte, and Atlanta.
New cities buy in as franchises, like NFL expansion teams.



Gate: each spoke proves its own demand before public money is committed

Phase 4: Regional networks in other dense corridors

Copy the model where demand is dense: the Texas Triangle, California, the Pacific Northwest.
One league, one safety standard, pods that can run on any line.

Every later phase has a gate it must clear before new public money goes in. Phase 3 spokes would follow the same logic as the NEC: go where trips between big cities are dense and the distances are long enough that a 600 mph pod wins, but short enough that flying is a hassle.

Grow only where trips are dense, and only after the last phase pays off

Phase 3 and 4 lines are illustrative corridors, not surveyed routes.

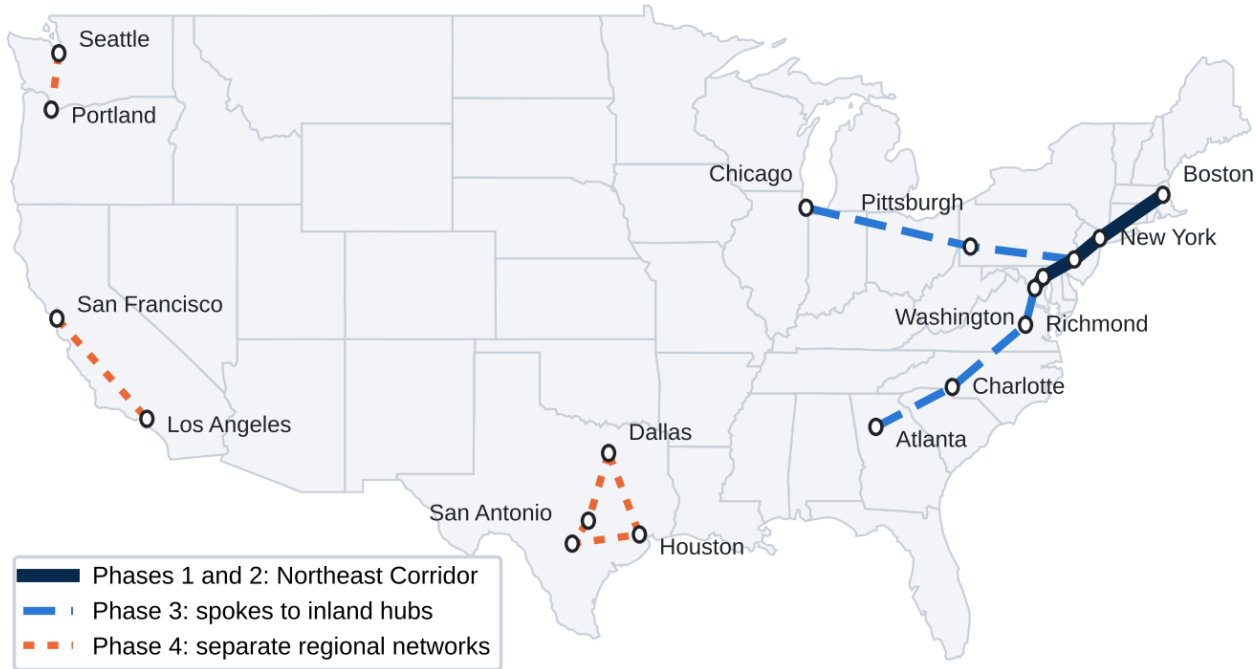


Figure 8. Illustrative expansion network. Phase 3 spokes and Phase 4 regional networks would each need their own demand case before any public money is committed.

15. Risks we see

Risk	Likelihood	Impact	What we'd do
Build costs run past \$40B	High	High	Gate every phase on real cost per mile from Phase 1
Air-bearing energy use is too high	Medium	Medium	Test it in Phase 1b; switch to magnets if needed
Ridership falls short of 23M	Medium	High	Lean on freight; add bigger pods instead of more tube
Taxpayers won't fund stations	Medium	High	Value capture and profit-sharing guardrails
Regulation stays unclear	High	High	Push for a lead agency before major spending
Upgraded Amtrak takes the same riders	Medium	Medium	Target drivers and flyers, not just rail riders
A serious accident	Low	Very high	Freight-first operations and one league-wide safety standard

16. Conclusion

The hyperloop conversation so far has been about the pod: how fast it goes, how it floats, how it brakes. Those are the problems we've spent the last year working on, and they matter. But a working pod doesn't build a tube.

What decides whether hyperloop happens is where the first line goes and who pays for it. Our answer is the Northeast Corridor, because it is the only US route with enough riders and freight to carry the fixed cost, and a league model, because it splits the work between the public and private sides the way they are each built to handle. Start with Philadelphia to New York, prove the numbers, and grow from there.

2026 Update

This section was added in 2026. Everything before it reflects what we knew and argued in 2016.

What happened since

- **Air bearings vs. magnets.** Virgin Hyperloop tested air bearings in a near-vacuum and found the compressor needed far too much power, so it switched to magnetic levitation. That confirmed the exact risk we flagged: energy use was the make-or-break question for our approach.
- **The industry stalled.** Hyperloop One (formerly Virgin Hyperloop) raised over \$400 million, ran the first human test in 2020, and shut down at the end of 2023 without winning a contract to build a real line. Its last pivot, under port operator DP World, was toward cargo.
- **The NEC got tested.** The Boring Company proposed a DC to Baltimore tunnel described as "hyperloop-compatible." Its federal environmental review is now listed as paused. USDOT created a council in 2019 just to sort out which agency regulates technologies like this, which is the "no rulebook" problem we described.
- **Demand kept growing.** Amtrak's NEC ridership hit about 15 million trips in fiscal 2025, up from 11.9 million in 2016. The Port of New York and New Jersey grew to about 8.9 million TEUs in 2025. The Northeast Corridor Commission now says the region produces about 20% of US GDP on 2% of the land.

What I'd change

The core argument held up: the companies that failed had working vehicles but no route with enough demand and no owner who could carry the tube. I'd keep the NEC route and the league model, and I'd lead with freight in Phase 1, since that's where the last serious player ended up anyway.

What I learned

The pod was never the hard part. Fundraising as students, and learning that just shipping the pod would cost about \$40,000, taught me that money constraints change engineering decisions in real time. Now I start any project by asking where demand is densest and who pays the fixed costs, then pick the technology that fits.

Appendix A: Calculations and assumptions

Yearly capital payment

Payment = Build cost $\times r / (1 - (1 + r)^{-n})$, with $r = 5\%$ and $n = 40$ years. The factor works out to 0.0583, so a \$40 billion build costs about \$2.33 billion a year.

Rides needed

Rides per year = Yearly payment / margin per ride. At \$2.33 billion and \$100 per ride, that's about 23.3 million rides.

Capacity

Seats per hour each way = (3,600 / seconds between pods) $\times$ seats per pod. Seats per year = seats per hour $\times$ 18 hours $\times$ 365 days. To carry 23 million rides (11.5 million each way) at 70% full, the line needs about 16.4 million seats each way, or about 2,500 per hour, which is about 89 pods an hour, one every 40 seconds.

Travel times

Pods speed up and slow down at 0.5 g (about 4.9 m/s^2) to a 600 mph cruise, which takes about 55 seconds and 4.6 miles each way. The rest of the trip is at 600 mph. We add about 6 minutes per trip for slower running in city tunnels and station approaches. Real alignments with curves would add more.

Key assumptions

Assumption	Value	Notes
Corridor build cost	\$40B	About \$88M per mile over 457 miles
Financing	5%, 40 years	Public infrastructure terms
Margin per ride	\$100	After operating costs
Seats per pod	28	Alpha's passenger pod; bigger pods would help capacity
Operating hours	18 per day for passengers	Overnight reserved mostly for freight
Load factor	70%	Average share of seats filled
Cruise speed	600 mph	Below Alpha's 760 mph top speed to allow for curves

Appendix B: Glossary

Term	Meaning
Air bearing	A thin cushion of pressurized air that lets an object float with almost no friction, like an air hockey puck
Magnetic levitation (maglev)	Using magnets to lift a vehicle off its track
Headway	Time between one pod leaving and the next one leaving
Load factor	Share of seats that are actually filled
Right-of-way (ROW)	The strip of land a road, railroad, or tube is built on
TEU	Twenty-foot equivalent unit, the standard way to count shipping containers
NEC	Northeast Corridor, the Washington to Boston rail line and region
NEPA review	The federal environmental review required for federally funded projects
RRIF / TIFIA	Federal loan programs for rail and transportation infrastructure
Value capture	Using the rise in nearby property values from a project to help pay for it

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About this edition

The Drexel Hyperloop business team originally wrote this proposal in 2016 as a supporting document for our SpaceX Hyperloop Pod Competition entry. The original files were lost after the team disbanded. As business team lead for Drexel Hyperloop, I (Yoshi Mua) reconstructed it in October 2026 from memory of the arguments we made. In this edition I also expanded the supporting analysis, including the capacity math, sensitivity tables, competing-projects comparison, Phase 1 detail, appendices, and the charts, maps, and concept illustrations, using only facts and numbers that were available in 2016. Everything that came later is kept separate in the 2026 Update.