[Template:Use mdy dates](/wiki/Template:Use_mdy_dates" \o "Template:Use mdy dates) [thumb|Concept design of Hyperloop](/wiki/File:Hyperloop_no_tube.png) [thumb|Concept art of Hyperloop inner workings](/wiki/File:Hyperloop_all_cutaway.png) **Hyperloop** is a tradename and a registered trademark of the [Space Exploration Technologies Corporation](/wiki/Space_Exploration_Technologies_Corporation) for the high speed transportation of passengers and goods in tubes[[1]](#cite_note-1)[[2]](#cite_note-2) in which capsules are propelled by [linear induction motors](/wiki/Linear_induction_motor) and [air compressors](/wiki/Air_compressor).[[3]](#cite_note-3) Recently there has been a resurgence in interest in [pneumatic tube transportation systems](/wiki/Vactrain) since being reintroduced using updated technologies, by [Elon Musk](/wiki/Elon_Musk),[[4]](#cite_note-4)[[5]](#cite_note-5) incorporating reduced-pressure tubes in which pressurized capsules ride on an air cushion driven by [linear induction motors](/wiki/Linear_induction_motor) and [air compressors](/wiki/Air_compressor).[[3]](#cite_note-3) The outline of the original Hyperloop concept was made public by the release of a preliminary design document in August 2013, which included a notional route running from the [Los Angeles](/wiki/Los_Angeles) region to the [San Francisco Bay Area](/wiki/San_Francisco_Bay_Area), paralleling the [Interstate 5](/wiki/Interstate_5_in_California) corridor for most of its length. Preliminary analysis indicated that such a route might obtain an expected journey time of 35 minutes, meaning that passengers would traverse the [Template:Convert](/wiki/Template:Convert) route at an average speed of around [Template:Convert](/wiki/Template:Convert), with a top speed of [Template:Convert](/wiki/Template:Convert). Preliminary cost estimates for the LA–SF notional route were included in the white paper—[Template:USD](/wiki/Template:USD) for a passenger-only version, and [Template:USD](/wiki/Template:USD) for a somewhat larger-diameter version transporting passengers and vehicles[[5]](#cite_note-5) —although transportation analysts doubted that the system could be constructed on that budget.[[6]](#cite_note-6)[[7]](#cite_note-7)[[8]](#cite_note-8) Hyperloop technology has been explicitly [open-sourced](/wiki/Open-source_hardware) by Musk and SpaceX, and others have been encouraged to take the ideas and further develop them. To that end, several companies have been formed, and dozens of interdisciplinary student-led teams are working to advance the technology.[Template:Citation needed](/wiki/Template:Citation_needed)

Designs for test tracks and capsules are currently being developed, with construction of a full-scale prototype [Template:Convert](/wiki/Template:Convert) track scheduled to start in 2016.[[9]](#cite_note-9) In addition, a [subscale](/wiki/Scale_model) [pod design competition](/wiki/Hyperloop_pod_competition) on a very short, [Template:Convert](/wiki/Template:Convert), test track was built in Nevada – the first tests of the scale model occurred in May 2016.<ref name=verge20160130/>

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## History[[edit](/index.php?title=(none)&action=edit&section=1)]

The general idea of trains or other transportation traveling through [evacuated tubes](/wiki/Vactrain) dates back more than a century although the [atmospheric railway](/wiki/Atmospheric_railway) was never a commercial success. [Elon Musk's](/wiki/Elon_Musk) Hyperloop may make the idea economically viable [Template:Citation needed](/wiki/Template:Citation_needed).

Musk first mentioned that he was thinking about a concept for a "fifth mode of transport", calling it the *Hyperloop*, in July 2012 at a [PandoDaily](/wiki/PandoDaily) event in [Santa Monica, California](/wiki/Santa_Monica,_California). This hypothetical high-speed mode of transportation would have the following characteristics: immunity to weather, collision free, twice the speed of a plane, low power consumption, and energy storage for 24-hour operations.[[10]](#cite_note-10) The name *Hyperloop* was chosen because it would go in a loop. Musk envisions the more advanced versions will be able to go at [hypersonic speed](/wiki/Hypersonic_speed).[[11]](#cite_note-11) In May 2013, Musk likened the Hyperloop to a "cross between a [Concorde](/wiki/Concorde) and a [railgun](/wiki/Railgun) and an [air hockey](/wiki/Air_hockey) table,",[[12]](#cite_note-12) he also believes it could work either below or above ground.[[13]](#cite_note-13) From late 2012 until August 2013, a group of engineers from both [Tesla](/wiki/Tesla_Motors) and [SpaceX](/wiki/SpaceX) worked on the conceptual modelling of Hyperloop.[[14]](#cite_note-14) An early system design was published in to the Tesla and SpaceX blogs.[[5]](#cite_note-5)[[15]](#cite_note-15) Musk has also invited feedback to "see if the people can find ways to improve it". The Hyperloop will be an [open source](/wiki/Open_source) design.[[16]](#cite_note-16) The following day he announced a plan to demonstrate the project.[[14]](#cite_note-14)[Template:Update after](/wiki/Template:Update_after)

In June 2015, SpaceX announced that it would build a [Template:Convert](/wiki/Template:Convert) test track to be located next to SpaceX's [Hawthorne](/wiki/Hawthorne,_California) facility. The track would be used to test pod designs supplied by third parties in the competition.[[17]](#cite_note-17)[[18]](#cite_note-18) Construction on a [Template:Convert](/wiki/Template:Convert) Hyperloop test track is to start on a [Hyperloop Transportation Technologies](/wiki/Hyperloop_Transportation_Technologies)-owned site in [Quay Valley](/wiki/Quay_Valley,_California) in 2016.[[19]](#cite_note-19)[[20]](#cite_note-20) By November 2015, with several commercial companies and dozens of student teams pursuing the development of Hyperloop technologies, the [Wall Street Journal](/wiki/Wall_Street_Journal) asserted that "The Hyperloop Movement, as some of its unaffiliated members refer to themselves, is officially bigger than the man who started it."<ref name=wsj20151130> [Template:Cite news](/wiki/Template:Cite_news)</ref>

## Theory and operation[[edit](/index.php?title=(none)&action=edit&section=2)]

[thumb|Artist's impression of a Hyperloop capsule:](/wiki/File:Hyperloop_capsule.svg) [Air compressor](/wiki/Air_compressor) on the front, passenger compartment in the middle, battery compartment at the back, and [air caster](/wiki/Air_caster) skis at the bottom [thumb|A 3D sketch of the Hyperloop infrastructure. The steel tubes are rendered transparent in this image.](/wiki/File:Hyperloop.jpg)

Developments in [high-speed rail](/wiki/High-speed_rail) have historically been impeded by the difficulties in managing [friction](/wiki/Friction) and [air resistance](/wiki/Air_resistance), both of which become substantial when vehicles approach high speeds. The [vactrain](/wiki/Vactrain) concept theoretically eliminates these obstacles by employing [magnetically levitating](/wiki/Maglev) trains in [evacuated](/wiki/Vacuum) (airless) or partly evacuated tubes, allowing for speeds of thousands of miles per hour. However, the high cost of maglev and the difficulty of maintaining a vacuum over large distances has prevented this type of system from ever being built. The Hyperloop resembles a vactrain system but operates at approximately [Template:Convert](/wiki/Template:Convert) of pressure.[[21]](#cite_note-21)

### Initial design concept[[edit](/index.php?title=(none)&action=edit&section=3)]

The Hyperloop concept operates by sending specially designed "capsules" or "pods" through a continuous steel tube maintained at a partial vacuum. Each capsule floats on a [Template:Convert](/wiki/Template:Convert) layer of air provided under pressure to [air-caster](/wiki/Air_caster) "skis", similar to how pucks are suspended in an [air hockey](/wiki/Air_hockey) table, thus avoiding the use of [maglev](/wiki/Maglev) while still allowing for speeds that wheels cannot sustain. [Linear induction motors](/wiki/Linear_induction_motor) located along the tube would accelerate and decelerate the capsule to the appropriate speed for each section of the tube route. With [rolling resistance](/wiki/Rolling_resistance) eliminated and air resistance greatly reduced, the capsules can [glide](/wiki/Gliding_flight) for the bulk of the journey. In the Hyperloop concept, an electrically driven [inlet fan](/wiki/Ducted_fan) and [air compressor](/wiki/Air_compressor) would be placed at the nose of the capsule to "actively transfer high pressure air from the front to the rear of the vessel," resolving the problem of air pressure building in front of the vehicle, slowing it down.[[5]](#cite_note-5) A fraction of the air is shunted to the skis for additional pressure, augmenting that gain passively from lift due to their shape.

In the alpha-level concept, passenger-only pods are to be [Template:Convert](/wiki/Template:Convert) in diameter[[5]](#cite_note-5) and projected to reach a top speed of [Template:Convert](/wiki/Template:Convert) to maintain aerodynamic efficiency;[Template:Citation needed](/wiki/Template:Citation_needed) the design proposes passengers experience a maximum inertial acceleration of 0.5 g, about 2 or 3 times that of a commercial airliner on takeoff and landing. At those speeds there would not be a [sonic boom](/wiki/Sonic_boom).[[22]](#cite_note-22)

### Notional routes[[edit](/index.php?title=(none)&action=edit&section=4)]

A number of routes have been proposed for Hyperloop systems that meet the approximate distance conditions for which a Hyperloop is hypothesized to provide improved transport times .

The [notional](/wiki/Wikt:notional) route sized out in the 2013 alpha-level design document was from the [Greater Los Angeles Area](/wiki/Greater_Los_Angeles_Area) to the [San Francisco Bay Area](/wiki/San_Francisco_Bay_Area). That conceptual system would begin around [Sylmar](/wiki/Sylmar,_California), just south of the [Tejon Pass](/wiki/Tejon_Pass), follow [Interstate 5](/wiki/Interstate_5_in_California) to the north, and arrive near [Hayward](/wiki/Hayward,_California) on the east side of San Francisco Bay. Several proposed branches were also shown in the design document, including [Sacramento](/wiki/Sacramento,_California), [Anaheim](/wiki/Anaheim,_California), [San Diego](/wiki/San_Diego), and [Las Vegas](/wiki/Las_Vegas_Valley).[[5]](#cite_note-5) European routes have been put forward in January 2016. A [Paris](/wiki/Paris) to [Amsterdam](/wiki/Amsterdam) notional route was proposed by [Delft Hyperloop](/wiki/Delft_Hyperloop).[[23]](#cite_note-23)[[24]](#cite_note-24)A [Warsaw University of Technology](/wiki/Warsaw_University_of_Technology) team is evaluating potential routes from [Cracow](/wiki/Cracow) to [Gdańsk](/wiki/Gdańsk) across [Poland](/wiki/Poland) proposed by [Hyper Poland](/wiki/Hyper_Poland).<ref name=itkey20160217> [Template:Cite news](/wiki/Template:Cite_news)</ref>

[Hyperloop Transportation Technologies](/wiki/Hyperloop_Transportation_Technologies) (HTT) is one group that has been exploring routes other than the Los Angeles to San Francisco route.[[25]](#cite_note-25) Another company, [Hyperloop One](/wiki/Hyperloop_One) (formerly Hyperloop Technologies), has proposed a route from Los Angeles to [Las Vegas](/wiki/Las_Vegas).[[26]](#cite_note-26) Observers and analysts have begun to weigh in on some of these potential routes. For example, for the alpha-design notional route, observers have noted that while terminating the Hyperloop route on the fringes of the two major metropolitan areas (Los Angeles and San Francisco) would result in significant cost savings in construction, it would require that passengers traveling to and from [Downtown Los Angeles](/wiki/Downtown_Los_Angeles) and San Francisco, and any other community beyond Sylmar and Hayward, to transfer to another transportation mode in order to reach their final destination. This would significantly lengthen the total travel time to those destinations.[[27]](#cite_note-27) A similar problem already affects present day air travel, where on short routes (like LAX-SFO) the flight time is only a rather small part of door to door travel time. Critics have argued that this would significantly reduce the proposed cost and/or time savings of Hyperloop as compared to the [California High-Speed Rail](/wiki/California_High-Speed_Rail) project that will serve downtown stations in both San Francisco and Los Angeles.[[28]](#cite_note-28)[[29]](#cite_note-29)[[30]](#cite_note-30) Passengers travelling financial centre to financial centre are estimated to save just about two hours by taking the hyperloop instead of driving the whole distance.[[31]](#cite_note-31) Others questioned the cost projections for the notional California route. Some transportation engineers argued in 2013 that they found the alpha-level design cost estimates unrealistically low given the scale of construction and reliance on unproven technology. The technological and [economic feasibility](/wiki/Economic_feasibility) of the idea is unproven and a subject of significant debate.[[6]](#cite_note-6)[[7]](#cite_note-7)[[8]](#cite_note-8)[[27]](#cite_note-27) HTT signed an agreement with the government of Slovakia in March 2016 to perform impact studies, with potential links between [Bratislava](/wiki/Bratislava), [Vienna](/wiki/Vienna) and [Budapest](/wiki/Budapest).[[32]](#cite_note-32) Since May 2016, the Russian railway company [Russian Railways](/wiki/Russian_Railways) has been working together with the U.S. company [Hyperloop One](/wiki/Hyperloop_One) to plan a route connecting the major cities of [Moscow](/wiki/Moscow) and [Saint Petersburg](/wiki/Saint_Petersburg) primarily for cargo transports.[[33]](#cite_note-33)[[34]](#cite_note-34)

### Open-source design evolution[[edit](/index.php?title=(none)&action=edit&section=5)]

In September 2013, [Ansys](/wiki/Ansys) Corporation ran [computational fluid dynamics](/wiki/Computational_fluid_dynamics) simulations to model the aerodynamics of the capsule and [shear stress](/wiki/Shear_stress) forces that the capsule would be subjected to. The simulation showed that the capsule design would need to be significantly reshaped to avoid creating [supersonic](/wiki/Supersonic) airflow, and that the gap between the tube wall and capsule would need to be larger.[[35]](#cite_note-35)[[36]](#cite_note-36) Ansys employee Sandeep Sovani said the simulation showed that Hyperloop has challenges but that he is convinced it is feasible.[[35]](#cite_note-35) In October 2013, the development team of the [OpenMDAO](/wiki/OpenMDAO) software framework released an unfinished, conceptual open-source model of parts of the Hyperloop's propulsion system. The team asserted that the model demonstrated the concept's feasibility, although the tube would need to be [Template:Convert](/wiki/Template:Convert) in diameter,[[37]](#cite_note-37) significantly larger than originally projected. However, the team's model is not a true working model of the propulsion system, as it did not account for a wide range of technological factors required to physically construct a Hyperloop based on Musk's concept, and in particular had no significant estimations of component weight.[[38]](#cite_note-38) In November 2013, [MathWorks](/wiki/MathWorks) analyzed the proposal's suggested route and concluded that the route was mainly feasible. The analysis focused on the acceleration experienced by passengers and the necessary deviations from public roads in order to keep the accelerations reasonable; it did highlight that maintaining a trajectory along I-580 east of San Francisco at the planned speeds was not possible without significant deviation into heavily populated areas.[[39]](#cite_note-39) In January 2015, a paper based on the NASA [OpenMDAO](/wiki/OpenMDAO) open-source model reiterated the need for a larger diameter tube and a reduced cruise speed closer to Mach 0.85. It also recommended removing on-board heat exchangers based on thermal models from the interactions between the compressor cycle, tube, and ambient environment. The compression cycle would only contribute 5% of the heat added to the tube, with 95% of the heat attributed to radiation and convection into the tube. The weight and volume penalty of on-board heat exchangers would not be worth the minor benefit, and regardless the steady-state temperature in the tube would only reach [Template:Convert](/wiki/Template:Convert) above ambient temperature.[[40]](#cite_note-40) Musk has allowed that various aspects and subsystems of hyperloop have technology applications to other Musk interests, including [surface transportation on Mars](/wiki/Surface_transportation_on_Mars) and [electric jet propulsion](/wiki/Musk_electric_jet).<ref name=fortune20160131>[Template:Cite news](/wiki/Template:Cite_news)</ref><ref name=musk20160130>[Template:Cite AV media](/wiki/Template:Cite_AV_media)</ref>

### Mars[[edit](/index.php?title=(none)&action=edit&section=6)]

According to Musk, Hyperloop would be useful on Mars as no tubes would be needed. This is because Mars' atmosphere is about 1% the density of the Earth's.[[11]](#cite_note-11)[[41]](#cite_note-41)[[42]](#cite_note-42) For the hyperloop concept to work on Earth, low-pressure tubes are required to reduce air resistance. However, if they were to be built on Mars, the lower air resistance would allow a hyperloop to be created with no tube, only a track.[[43]](#cite_note-43)

## Groups acquiring funding and building hardware[[edit](/index.php?title=(none)&action=edit&section=7)]

Funding to operate prototype Hyperloop vehicles on test tracks are now underway by three companies. Hyperloop Transportation Technologies is building a [Template:Convert](/wiki/Template:Convert) in Quay Valley, California; SpaceX is building a [Template:Convert](/wiki/Template:Convert)-[track](/wiki/SpaceX_Hypertube_test_track) in Hawthorne, California; and Hyperloop One is building a test track in [North Las Vegas, Nevada](/wiki/North_Las_Vegas,_Nevada).<ref name=wsj20151130/><ref name=gcr20160131>[Template:Cite news](/wiki/Template:Cite_news)</ref>

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### Hyperloop One (Previously Hyperloop Technologies)[[edit](/index.php?title=(none)&action=edit&section=8)]

[Hyperloop One](/wiki/Hyperloop_One) announced in February 2015 their plan to develop a Hyperloop route between Los Angeles and Las Vegas. They have organized a [board of directors](/wiki/Board_of_directors) and an engineering team, and have raised more than [Template:USD](/wiki/Template:USD) in working capital.[[44]](#cite_note-44) Hyperloop One consists of over 100 engineers. [Shervin Pishevar](/wiki/Shervin_Pishevar), a venture capitalist with strong connections to Elon Musk is one of the two co-founders. A lead engineer for Musk's [SpaceX](/wiki/SpaceX), Brogan BamBrogan, is the other co-founder. There are many other connections to Musk throughout Hyperloop One. [David Sacks](/wiki/David_O._Sacks) is on the board of directors and he worked under Musk at PayPal. Even though Elon Musk isn’t directly a part of this organization, he is constantly updated.[[45]](#cite_note-45) On May 11, 2016 Hyperloop One conducted the first live trial of Hyperloop technology.[[46]](#cite_note-46)

### Hyperloop Transportation Technologies[[edit](/index.php?title=(none)&action=edit&section=9)]

[Hyperloop Transportation Technologies](/wiki/Hyperloop_Transportation_Technologies) (HTT) is a group of 500 part-time engineers located across the United States who collaborate through weekly teleconferences. Rather than being paid directly, members work in exchange for [stock options](/wiki/Stock_option). The company is projecting the completion of a technical feasibility study in 2015, but have said that it is at least ten years away from a commercially operating Hyperloop.[[25]](#cite_note-25) HTT announced in May 2015 that a deal had been finalized with landowners to build a [Template:Convert](/wiki/Template:Convert) test track along a stretch of road near [Interstate 5](/wiki/Interstate_5) between Los Angeles and San Francisco.[[47]](#cite_note-47) Later in 2015, HTT announced partnerships with [Oerlikon Leybold Vacuum](/wiki/Oerlikon_Leybold_Vacuum) and [AECOM](/wiki/AECOM) to assist in the development and construction of the test track,[[9]](#cite_note-9) located in the planned community of [Quay Valley](/wiki/Quay_Valley), beginning in November 2015 and estimated to take 32 months to complete at a cost of [Template:USD](/wiki/Template:USD).[[48]](#cite_note-48) Passenger capsules will accelerate to [Template:Convert](/wiki/Template:Convert), while empty capsules will be tested at the full [Template:Convert](/wiki/Template:Convert).[[48]](#cite_note-48)

### TransPod[[edit](/index.php?title=(none)&action=edit&section=10)]

TransPod in 2016 introduced a new pod design as a prototype vehicle for field testing. In March 2016, TransPod announced that they will present a full-scale concept vehicle design at the InnoTrans Rail Show in Berlin in September 2016.[[49]](#cite_note-49) The TransPod vehicle is planned to target speeds in excess of 1000 km/h, based on computer-driven control, with infrastructure capable of being solar-powered.[[50]](#cite_note-50)TransPod has announced a plan to produce a commercial vehicle by 2020.[[51]](#cite_note-51)and to work with regulatory agencies for approval of its first hyperloop lines between 2020-2025.[[52]](#cite_note-52)The Montreal-Toronto corridor is one of the lines under consideration by TransPod.[[53]](#cite_note-53) TransPod has headquarters in Toronto. It is collaborating with aerospace companies, university researchers, and an architecture firm in Europe. [[49]](#cite_note-49)[[53]](#cite_note-53)[[54]](#cite_note-54)[[55]](#cite_note-55)

## Hyperloop pod competition[[edit](/index.php?title=(none)&action=edit&section=11)]

[Template:Main article](/wiki/Template:Main_article)

A number of student and non-student teams are participating in a [Hyperloop pod competition](/wiki/Hyperloop_pod_competition) in 2015–2016, and at least 22 of them will build hardware to compete on a sponsored hyperloop test track in mid-2016.<ref name=verge20160130>[Template:Cite news](/wiki/Template:Cite_news)</ref>

In June 2015, SpaceX announced that they would sponsor a Hyperloop pod design competition, and would build a [Template:Convert](/wiki/Template:Convert) subscale test track near SpaceX's headquarters in [Hawthorne](/wiki/Hawthorne,_California), California, for the competitive event in 2016.[[56]](#cite_note-56)[[57]](#cite_note-57) SpaceX stated in their announcement, "Neither SpaceX nor Elon Musk is affiliated with any Hyperloop companies. While we are not developing a commercial Hyperloop ourselves, we are interested in helping to accelerate development of a functional Hyperloop prototype."[[58]](#cite_note-58) More than 700 teams had submitted preliminary applications by July,[[59]](#cite_note-59) and detailed competition rules were released in August.<ref name=rules\_v20/> *Intent to Compete* submissions were due in September 2015 with more detailed tube and technical specification released by SpaceX in October. A preliminary design briefing was held in November 2015,<ref name=gw20151215/> where more than 120 student engineering teams were selected to submit *Final Design Packages* due by January 13, 2016.<ref name=gw20151215>[Template:Cite news](/wiki/Template:Cite_news)</ref>

A *Design Weekend* was held at [Texas A&M University](/wiki/Texas_A&M_University) January 29–30, 2016, for all invited entrants.[[60]](#cite_note-60) Engineers from the [Massachusetts Institute of Technology](/wiki/Massachusetts_Institute_of_Technology) were named the winners of the competition. Finishing second was [Delft University of Technology](/wiki/Delft_University_of_Technology) from the Netherlands, followed by the [University of Wisconsin–Madison](/wiki/University_of_Wisconsin–Madison), [Virginia Tech](/wiki/Virginia_Tech), and the [University of California, Irvine](/wiki/University_of_California,_Irvine).[[61]](#cite_note-61)[[62]](#cite_note-62) While the MIT team took best overall, Delft University won the Pod Innovation Award.[[63]](#cite_note-63) 22 teams will be invited to build hardware and compete in time trials later in 2016 at Hawthorne, California.[[61]](#cite_note-61)[[64]](#cite_note-64)

## Human factors considerations[[edit](/index.php?title=(none)&action=edit&section=12)]

Some critics of Hyperloop focus on the experience—possibly unpleasant and frightening—of riding in a narrow, sealed, and windowless capsule inside a sealed steel tunnel, that is subjected to significant acceleration forces; high noise levels due to air being compressed and ducted around the capsule at near-sonic speeds; and the vibration and jostling.[[65]](#cite_note-65) Even if the tube is initially smooth, ground may shift due to seismic activity. At speeds approaching [Template:Convert](/wiki/Template:Convert), deviations of [Template:Convert](/wiki/Template:Convert) from a straight path would add considerable buffeting and vibration, with no provisions for passengers to stand, move within the capsule, use a restroom during the trip, or get assistance or relief in case of illness or motion sickness.[[66]](#cite_note-66) This is in addition to the obvious practical and logistical questions regarding how to best deal with equipment malfunction, accidents, and emergency evacuations.

## Political and economic considerations[[edit](/index.php?title=(none)&action=edit&section=13)]

The alpha proposal projected that cost savings compared with conventional rail would come from a combination of several factors. The small profile and elevated nature of the alpha route would enable Hyperloop to be constructed primarily in the median of [Interstate 5](/wiki/Interstate_5). However, whether this would be truly feasible is a matter of debate. The low profile would reduce tunnel boring requirements and the light weight of the capsules is projected to reduce construction costs over conventional passenger rail. It was asserted that there would be less [right-of-way](/wiki/Right-of-way) opposition and environmental impact as well due to its small, sealed, elevated profile versus that of a rail easement;[[5]](#cite_note-5) however, other commentators contend that a smaller footprint does not guarantee less opposition.[[27]](#cite_note-27) In criticizing this assumption, [mass transportation](/wiki/Mass_transportation) writer Alon Levy said,[[67]](#cite_note-67) "In reality, an all-elevated system (which is what Musk proposes with the Hyperloop) is a bug rather than a feature. Central Valley land is cheap; pylons are expensive, as can be readily seen by the costs of elevated highways and trains all over the world".[[68]](#cite_note-68) Michael Anderson, a professor of agricultural and resource economics at [UC Berkeley](/wiki/UC_Berkeley), predicted that costs would amount to around [Template:USD](/wiki/Template:USD).[[7]](#cite_note-7) The Hyperloop white paper suggests that [Template:USD](/wiki/Template:USD) of each one-way passenger ticket between Los Angeles and San Francisco would be sufficient to cover initial [capital costs](/wiki/Capital_(economics)), based on amortizing the cost of Hyperloop over 20 years with ridership projections of 7.4 million per year in each direction and does not include operating costs (although the proposal asserts that electric costs would be covered by solar panels). No total ticket [price](/wiki/Price) was suggested in the alpha design.[[5]](#cite_note-5) The projected ticket price has been questioned by Dan Sperling, director of the [Institute of Transportation Studies](/wiki/Institute_of_Transportation_Studies) at [UC Davis](/wiki/UC_Davis), who told [Al Jazeera America](/wiki/Al_Jazeera_America) that "there's no way the economics on that would ever work out."[[7]](#cite_note-7) The early cost estimates of the Hyperloop are a subject of debate. A number of economists and transportation experts have expressed the belief that the [Template:USD](/wiki/Template:USD) price tag dramatically understates the cost of designing, developing, constructing and testing an all-new form of transportation.[[6]](#cite_note-6)[[7]](#cite_note-7)[[27]](#cite_note-27)[[68]](#cite_note-68) *The Economist* said that the estimates are unlikely to "be immune to the [hypertrophication of cost](/wiki/Cost_overrun) that every other grand infrastructure project seems doomed to suffer."[[69]](#cite_note-69) Political impediments to the construction of such a project in California will be very large. There is a great deal of "political and [reputation capital](/wiki/Reputation_capital)" invested in the existing mega-project of [California High-Speed Rail](/wiki/California_High-Speed_Rail).[[69]](#cite_note-69) Replacing that with a different design would not be straightforward given California's political economy. Texas has been suggested as an alternate for its more amenable political and economic environment.[[69]](#cite_note-69) Building a successful Hyperloop sub-scale demonstration project could reduce the political impediments and improve cost estimates. Musk has suggested that he may be personally involved in building a demonstration prototype of the Hyperloop concept, including funding the development effort.[[14]](#cite_note-14)[[69]](#cite_note-69)

## Related projects[[edit](/index.php?title=(none)&action=edit&section=14)]

### Historical[[edit](/index.php?title=(none)&action=edit&section=15)]

The concept of transportation of passengers in pneumatic tubes is not new. The first patent to transport goods in tubes was taken out in 1799 by the British mechanical engineer and inventor [George Medhurst](/wiki/George_Medhurst). In 1812, Medhurst wrote a book detailing his idea of transporting passengers and goods through air-tight tubes using air propulsion.[[70]](#cite_note-70) In the early 1800s, there were other similar systems proposed or experimented with and were generally known as an [Atmospheric railway](/wiki/Atmospheric_railway).

The [Crystal Palace pneumatic railway](/wiki/Crystal_Palace_pneumatic_railway) operated in London around 1864 and used large fans, some [Template:Convert](/wiki/Template:Convert) in diameter, that were powered by a steam engine. The tunnels are now lost but the line operated successfully for over a year.

Operated from 1870 to 1873, the [Beach Pneumatic Transit](/wiki/Beach_Pneumatic_Transit) was a one block-long prototype of an underground tube transport public transit system in [New York City](/wiki/New_York_City). The system worked at near-atmospheric pressure, and the passenger car moved by means of higher-pressure air applied to the back of the car while somewhat lower pressure was maintained on the front of the car.[[71]](#cite_note-71) In the 1910s, vacuum trains were first described by American rocket pioneer [Robert Goddard](/wiki/Robert_Goddard).[[69]](#cite_note-69) While the Hyperloop has significant innovations over early proposals for reduced pressure or vacuum-tube transportation apparatus, the work of Goddard "appears to have the greatest overlap with the Hyperloop".[[3]](#cite_note-3) Princeton Physicist Gerard K. O'Neil, wrote about transcontinental trains using magnetic propulsion in his book "2081: A Hopeful View of the Human Future". While a work of fiction, this book was an attempt to predict future technologies in everyday life. In his prediction he envisioned these trains which used magnetic levitation running in underground tunnels which had much of the air evacuated to increase speed and reduce friction. He also demonstrated a scale prototype device that accelerated a mass using magnetic propulsion to high speeds. It was called a mass driver and was a central theme in his non-fiction book on space colonization "The High Frontier".

[Swissmetro](/wiki/Swissmetro) was a proposal to run a maglev train in a low-pressure environment. Concessions were granted to Swissmetro in the early 2000s to connect the Swiss cities of St. Gallen, Zurich, Basel, and Geneva. Studies of commercial feasibility reached differing conclusions and the vactrain were never built.[[72]](#cite_note-72) China was reported to be building a vacuum based [Template:Convert](/wiki/Template:Convert) maglev train in August 2010 according to a laboratory at Jiaotong University. It was expected to cost [Template:CNY](/wiki/Template:CNY) ([Template:USD](/wiki/Template:USD) at the August 2010 exchange rate) more per kilometre than regular high speed rail.[[73]](#cite_note-73) [Template:As of](/wiki/Template:As_of), it has not been built.

### Current[[edit](/index.php?title=(none)&action=edit&section=16)]

The [ET3 Global Alliance](/wiki/ET3_Global_Alliance) (ET3) was founded by Daryl Oster in 1997 with the goal of establishing a global transportation system using passenger capsules in frictionless [maglev](/wiki/Magnetic_levitation) full-vacuum tubes. Oster and his team met with Elon Musk on September 18, 2013, to discuss the technology,[[74]](#cite_note-74) resulting in Musk promising an investment in a [Template:Convert](/wiki/Template:Convert) prototype of ET3's proposed design.[[75]](#cite_note-75)[Template:Update after](/wiki/Template:Update_after)

## Popular culture[[edit](/index.php?title=(none)&action=edit&section=17)]

There are multiple examples of depressurized tubes in literature and media going back to the 19th century. [Harry Harrison's](/wiki/Harry_Harrison) [*Tunnel Through the Deeps*](/wiki/Tunnel_Through_the_Deeps) is an early [steampunk](/wiki/Steampunk) book that gives explicit details about how such a system would work both on land and at sea - including the use of underwater bridges to float the tubes across the depths beyond the continental shelf. [Gene Roddenberry's](/wiki/Gene_Roddenberry) follow-on to [Star Trek](/wiki/Star_Trek), [*Genesis II*](/wiki/Genesis_II_(film)), used a very similar concept – called a "subshuttle" in the programme – to move characters from place to place quickly.

## See also[[edit](/index.php?title=(none)&action=edit&section=18)]

* [Atmospheric railway](/wiki/Atmospheric_railway)
* [Ground effect train](/wiki/Ground_effect_train)
* [Kantrowitz limit](/wiki/Kantrowitz_limit)
* [Pneumatic tube](/wiki/Pneumatic_tube)
* [SkyTran](/wiki/SkyTran)

## References[[edit](/index.php?title=(none)&action=edit&section=19)]

[Template:Reflist](/wiki/Template:Reflist)

## External links[[edit](/index.php?title=(none)&action=edit&section=20)]

[Template:Commons category](/wiki/Template:Commons_category)

* Tesla Motors: [Template:PDFlink](/wiki/Template:PDFlink)
* SpaceX: [Template:PDFlink](/wiki/Template:PDFlink)
* [The Race to Create Elon Musk’s Hyperloop Heats Up](http://www.wsj.com/articles/the-race-to-create-elon-musks-hyperloop-heats-up-1448899356), *Wall Street Journal*, 2015.

[Template:High-speed rail](/wiki/Template:High-speed_rail) [Template:Emerging technologies](/wiki/Template:Emerging_technologies) [Template:Elon Musk](/wiki/Template:Elon_Musk)

[Category:Hyperloop](/wiki/Category:Hyperloop) [Category:Experimental vehicles](/wiki/Category:Experimental_vehicles) [Category:High-speed rail](/wiki/Category:High-speed_rail) [Category:Sustainable transport](/wiki/Category:Sustainable_transport) [Category:Transport systems](/wiki/Category:Transport_systems) [Category:Open hardware vehicles](/wiki/Category:Open_hardware_vehicles) [Category:Elon Musk](/wiki/Category:Elon_Musk) [Category:Linear induction motors](/wiki/Category:Linear_induction_motors)