**Group 9 – Elon Musk – Hyperlop**

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| *Assignment:*   * *Answer the following questions :*   + *Present Elon Musk hyperloop moonshot*   + *Why is it a moonshot?*   + *What are the OI practices ?* * *Each group has to present their answers in 10 minutes max in Chinese  (15minutes max including the time for the translator to translate each sentence in english)* |

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| *Article 1 -* [*RS Components*](https://www.globalrailwayreview.com/content_author/rs-components/) *(2018) How will hyperloop systems affect society and transport?*  *<https://www.globalrailwayreview.com/article/76047/hyperloop-systems-society-transport/>* |

**How will hyperloop systems affect society and transport?**

Said to be faster than trains, safer than cars and less damaging to the environment than aircrafts, hyperloop technology is quickly gaining traction. RS Components explores the benefits and challenges that the innovative mode of transport could have on society.

Elon Musk’s latest invention – hyperloop – is racing ahead, and is expected to be ready for commercial operations by 2021. But just how practical is this pod that shoots you through a vacuum at 700mph?

## Hyperloop as a common mode of transport

An American transportation technology company launched Virgin Hyperloop One in 2014, hyperloop’s leading contender, with the aim of working to commercialise the high-speed technology.

Noted as the 21st century’s biggest travel breakthrough, hyperloop is challenging all modes of transport in the race against time.

If every passenger trip between 500km and 1,500km that are currently made on flights, used hyperloop instead, emissions could be reduced yearly by 58 per cent.

Imagine the difference a three hour trip by train, reduced to 30 minutes, would make to all of our lives. In addition to this, prices are said to be comparable to that of intra-city public travel.

RS Components have analysed what public transport would look like if a hyperloop system replaced our current rail services into the capital of the country. You can view the interactive graphic [here](https://uk.rs-online.com/web/generalDisplay.html?id=i/hyperloop).

How much travel time could you save travelling from some of these major cities across the UK to London?

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| --- | --- | --- | --- | --- |
|  | **Hyperloop** | **National rail journey planner** | | |
| **City** | **Time taken (mins)** | **City to London (mins)** | **Time saved (mins)** | **How many times faster** |
| Coventry | 8 | 62 | 54 | 8x |
| Leicester | 8 | 65 | 57 | 8x |
| Birmingham | 9 | 83 | 74 | 9x |
| Stoke | 12 | 88 | 76 | 7x |
| Nottingham | 10 | 100 | 90 | 10x |
| Sheffield | 13 | 129 | 116 | 10x |
| Manchester | 14 | 125 | 111 | 9x |

## Implementation challenges

Although in theory it sounds fantastic, it is important to consider the several challenges hyperloop faces in both construction and its impact on society. The biggest speed bump hyperloop faces is the cost of the technology and elaborate tube system, estimated to cost millions of dollars.

The vehicle is transported by electric propulsion1 through a low-pressure tube and floats above the track using magnetic levitation. The long vacuum chamber manufacturing requires advanced technical skills which are costly and also risky to maintain. High risk to life, limited space in the train and land use rights are some other concerns and challenges that hyperloop will face, not to mention the installation would require a large number of trees to be cut down, leading to environmental loss.

However, it’s said to be two to three times faster than high-speed rail and will undoubtedly take the dread out of daily commutes. The engineering behind hyperloop has made it immune to bad weather conditions2, resistant to earthquakes and one of the safest modes of transportation. This would therefore reduce or completely eradicate the lengthy and annoying delays we all face on commutes to and from work.

## The potential benefits to society

Research figures show the journey from London to Birmingham would take nine minutes when using hyperloop or 83 minutes by national rail – a total saving of 74 minutes. Further distances include 22 minutes from London to Newcastle (saving 149 minutes), 29 minutes from London to Edinburgh (saving 231 minutes) and London to Glasgow only taking 31 minutes (saving 238 minutes). Shorter journeys into the capital will open up job opportunities and have a positive impact on tourism and sustainability.

Hyperloop will also improve access to education. With universities spread around the country, choosing one that’s right for you but isn’t too far from home is a challenge that many face when selecting their prospect university. However with city-to-city links via hyperloop reducing travel time massively, there is no longer a limit to selecting universities close to home.

Aside from travel time reduction, hyperloop will contribute towards solving the housing crisis. The cost of living in locations like London and San Francisco is pushing the poorest residents out due to financial instability. Therefore, by making travelling to places around the country cheaper, people will be more willing to live outside of the city. For example, travelling cheaply from Edinburgh to London would draw more people to live in Edinburgh, which has a significantly lower cost of living than London and a huge stock of houses available. Similarly, houses in Los Angeles are around 66 per cent cheaper than in San Francisco, with the travel time between the two only taking 30 minutes with hyperloop.

Each pod is estimated to hold up to 28 passengers, which is significantly less than your regular train or plane, however the aim is for each pod to leave every 30 seconds during rush hour and every two minutes on average.

Hyperloop is not only designed to carry passengers, but transport goods too. This will improve delivery time, avoid damage to packages and decrease the number of delivery cars, resulting in less emissions. The Netherlands have developed a capsule that does exactly this, the ‘Delft Hyperloop’ which carries both passengers and freight. The infrastructure for the tube is proposed to be above ground to reduce the cost of building underground or buying up land to use, and to avoid spoiling property of landowners.

Elon Musk said: “Hyperloop would inconvenience landowners no more than having a telephone pole on their property3.”

So what’s powering this major new form of transport? Electricity and solar power is the simple answer. The pods would get their velocity from an external linear electric motor, and the tube would have solar panels placed on top which would generate more energy. Therefore, only a small amount of electricity is needed to power hyperloop to its top speeds, making this one of the most environmentally friendly modes of transport alongside the electric car.

So how close are we to seeing these changes in society? Since the launch of hyperloop we’ve come a long way. In 2015, SpaceX built a mile-long test track; in 2016, MIT researchers showcased a prototype of the pod and then demonstrated the first ever [low-pressure run](https://www.youtube.com/watch?v=0JEZkczlTFk) a year later in 2017; in 2019, an offshoot company aim to build a full line in Abu Dhabi. These developments have led to thousands of job opportunities in engineering and technology. Research, development and testing are still underway, with millions of investors interested in developing the project.

Hyperloop is one of the most advanced technologies in transportation to date, and it has created a massive shift in human ingenuity. Whether it’s three years away or 30, Hyperloop poses some very effective and promising opportunities for society.

### References:

1. <https://hyperloop-one.com/facts-frequently-asked-questions>
2. <https://www.spacex.com/sites/spacex/files/hyperloop_alpha.pdf>
3. <https://nextcity.org/daily/entry/five-things-elon-musks-hyperloop-could-mean-for-the-future-of-cities>

*Article 2 : Hyperloop, Wikipedia, >*[*https://en.wikipedia.org/wiki/Hyperloop*](https://en.wikipedia.org/wiki/Hyperloop)*> (view on October 2021)*

A **Hyperloop** is a proposed high-speed mass transportation system for both [passenger](https://en.wikipedia.org/wiki/Public_transport) and [freight transport](https://en.wikipedia.org/wiki/Freight_transport).[[1]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-Motwani_37–45-1) The term was invented to describe the modern open-source project. Hyperloop is described as a sealed tube or system of tubes with low air pressure through which a pod may travel substantially free of [air resistance](https://en.wikipedia.org/wiki/Air_resistance) or friction.[[2]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:6-2) The Hyperloop could potentially move people or objects at airline speeds while being energy efficient compared with existing high-speed rail systems.[[2]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:6-2) This, if implemented, may reduce travel times compared to train and airplane travel[[2]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:6-2) over distances of under approximately 1,500 kilometres (930 miles).[[3]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:7-3)

It has three major components: a tube, pod, and terminal.[[1]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-Motwani_37–45-1) The tube is a large sealed, low-pressure system that can be constructed above or below ground. A coach runs inside this controlled environment and is often referred to as a pod. The pod employs magnetic or aerodynamic levitation (using air-bearing skis) along with electromagnetic or aerodynamic propulsion to glide along a fixed guideway. The terminals arrivals and departures.[[1]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-Motwani_37–45-1)

The Hyperloop concept has its roots in a concept invented by [George Medhurst](https://en.wikipedia.org/wiki/George_Medhurst) in 1799 and subsequently developed under the names pneumatic railway, [atmospheric railway](https://en.wikipedia.org/wiki/Atmospheric_railway) or [vactrain](https://en.wikipedia.org/wiki/Vactrain).[[4]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-4) [Elon Musk](https://en.wikipedia.org/wiki/Elon_Musk) mentioned the Hyperloop in 2012, bringing it back to public attention.[[5]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-PandoDaily_Hyperloop-5) His initial concept incorporated reduced-pressure tubes in which [pressurized](https://en.wikipedia.org/wiki/Pressurized) capsules ride on [air bearings](https://en.wikipedia.org/wiki/Air_bearing) driven by [linear induction motors](https://en.wikipedia.org/wiki/Linear_induction_motor) and [axial compressors](https://en.wikipedia.org/wiki/Axial_compressor).[[6]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-gm20130822-6) The Hyperloop Alpha concept was first published in August 2013, proposing and examining a route running from the [Los Angeles](https://en.wikipedia.org/wiki/Los_Angeles) region to the [San Francisco Bay Area](https://en.wikipedia.org/wiki/San_Francisco_Bay_Area), roughly following the [Interstate 5](https://en.wikipedia.org/wiki/Interstate_5_in_California) corridor. The Hyperloop Genesis paper conceived of a hyperloop system that would propel passengers along the 350-mile (560 km) route at a speed of 760 mph (1,200 km/h), allowing for a travel time of 35 minutes, which is considerably faster than current rail or air travel times. Preliminary cost estimates for this LA–SF suggested route were included in the white paper—[US$](https://en.wikipedia.org/wiki/United_States_dollar)6 billion for a passenger-only version, and US$7.5 billion for a somewhat larger-diameter version transporting passengers and vehicles.[[7]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-AlphaSpaceX-7) However, transportation analysts expressed doubts that the system could be constructed on that budget, including some predictions that the Hyperloop would be several billion dollars over budget once construction, development, and operation costs are taken into consideration.[[8]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-NYT-Bilton-8)[[9]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-AJE-9)[[10]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-HuffPoAstronomical-10)

The Hyperloop concept has been explicitly "[open-sourced](https://en.wikipedia.org/wiki/Open-source)" by Musk and [SpaceX](https://en.wikipedia.org/wiki/SpaceX), and others have been encouraged to take the ideas and further develop them. To that end, a few companies have been formed, and several interdisciplinary student-led teams are working to advance the technology.[[11]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-11) SpaceX built an approximately 1-kilometer-long (0.62 mi) [subscale](https://en.wikipedia.org/wiki/Scale_model) track for its [pod design competition](https://en.wikipedia.org/wiki/Hyperloop_pod_competition) at its headquarters in [Hawthorne, California](https://en.wikipedia.org/wiki/Hawthorne,_California).[[12]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-12) TUM Hyperloop set the world record of 463 km/h (288 mph) in July 2019 during the [Hyperloop pod competition](https://en.wikipedia.org/wiki/Hyperloop_pod_competition) at [SpaceX](https://en.wikipedia.org/wiki/SpaceX).[[13]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:8-13)[[14]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:9-14) [Virgin Hyperloop](https://en.wikipedia.org/wiki/Virgin_Hyperloop) conducted the first human trial in November 2020 at its test site in [Las Vegas](https://en.wikipedia.org/wiki/Las_Vegas).[[15]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-15)

## History

The vactrain concept was first proposed by [Robert H. Goddard](https://en.wikipedia.org/wiki/Robert_H._Goddard) in 1904.[[16]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-economist20130817-16)

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](https://en.wikipedia.org/wiki/PandoDaily) event in [Santa Monica, California](https://en.wikipedia.org/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.[[17]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-pandovideo-17) 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](https://en.wikipedia.org/wiki/Hypersonic_speed).[[18]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-youtube20160131-18) In May 2013, Musk likened the Hyperloop to a "cross between a [Concorde](https://en.wikipedia.org/wiki/Concorde) and a [railgun](https://en.wikipedia.org/wiki/Railgun) and an [air hockey](https://en.wikipedia.org/wiki/Air_hockey) table".[[19]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-atd20130530-19)

From late 2012 until August 2013, a group of engineers from both [Tesla](https://en.wikipedia.org/wiki/Tesla_Motors) and [SpaceX](https://en.wikipedia.org/wiki/SpaceX) worked on the conceptual modeling of Hyperloop.[[20]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-gm20130813-20) An early system design was published in the Tesla and SpaceX blogs[[7]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-AlphaSpaceX-7)[[21]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-AlphaTesla-21) which describes one potential design, function, pathway, and cost of a hyperloop system.[[7]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-AlphaSpaceX-7) According to the alpha design, pods would accelerate to cruising speed gradually using a linear electric motor and glide above their track on [air bearings](https://en.wikipedia.org/wiki/Air_bearings) through tubes above ground on columns or below ground in tunnels to avoid the dangers of [grade crossings](https://en.wikipedia.org/wiki/Grade_crossing). An ideal hyperloop system will be more energy-efficient,[[22]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-EDS_power_consumption-22)[[23]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-ESC_Hyperloop-23) quiet, and [autonomous](https://en.wikipedia.org/wiki/Vehicular_automation) than existing modes of mass transit. Musk has also invited feedback to "see if the people can find ways to improve it". The Hyperloop Alpha was released as an [open source](https://en.wikipedia.org/wiki/Open-source_model) design.[[24]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-globemail20130812-24) The word mark "*HYPERLOOP*", applicable to "high-speed transportation of goods in tubes" was issued to SpaceX on 4 April 2017.[[25]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-25)[[26]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-26)

In June 2015, SpaceX announced that it would build a 1-mile-long (1.6 km) [test track](https://en.wikipedia.org/wiki/Hyperloop_pod_competition#Test_track) to be located next to SpaceX's [Hawthorne](https://en.wikipedia.org/wiki/Hawthorne,_California) facility. The track would be used to test pod designs supplied by third parties in the competition.[[27]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-CNNmoney-15-6-15-27)[[28]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-SFchronicle-6-15-15-28)

By November 2015, with several commercial companies and dozens of student teams pursuing the development of Hyperloop technologies, the [*Wall Street Journal*](https://en.wikipedia.org/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."[[29]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-wsj20151130-29)

The MIT Hyperloop team developed the first Hyperloop pod prototype, which they unveiled at the MIT Museum on 13 May 2016. Their design uses [electrodynamic suspension](https://en.wikipedia.org/wiki/Electrodynamic_suspension) for levitating and [eddy current braking](https://en.wikipedia.org/wiki/Eddy_current_brake).[[30]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-30)

On 29 January 2017, approximately one year after phase one of the [Hyperloop pod competition](https://en.wikipedia.org/wiki/Hyperloop_pod_competition),[[31]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-31) the MIT Hyperloop pod demonstrated the first ever low-pressure Hyperloop run in the world.[[32]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-32) Within this first competition the [Delft University](https://en.wikipedia.org/wiki/TU_Delft) team from the Netherlands achieved the highest overall competition score, winning the prize for "best overall design".[[33]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-Delft-NLTimes-2017-01-30-33)[[34]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:0-34) The award for the "fastest pod" was won by the team WARR Hyperloop from the [Technical University of Munich (TUM)](https://en.wikipedia.org/wiki/Technical_University_of_Munich), Germany.[[35]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-35) The team from the [Massachusetts Institute of Technology (MIT)](https://en.wikipedia.org/wiki/Massachusetts_Institute_of_Technology) placed third overall in the competition, judged by SpaceX engineers.[[36]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-36)

The second Hyperloop pod competition took place from 25–27 August 2017. The only judging criterion was top speed, provided it was followed by successful deceleration. WARR Hyperloop from the [Technical University of Munich](https://en.wikipedia.org/wiki/Technical_University_of_Munich) won the competition by reaching a top speed of 324 km/h (201 mph) and therefore breaking the previous record of 310 km/h (190 mph) for Hyperloop prototypes set by [Hyperloop One](https://en.wikipedia.org/wiki/Hyperloop_One) on their own test track.[[37]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:1-37)[[38]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:2-38)[[39]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:3-39)

A third Hyperloop pod competition took place in July 2018. The defending champions, the WARR Hyperloop team from the Technical University of Munich, beat their own record with a top speed of 457 km/h (284 mph) during their run.[[40]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:4-40)

The fourth competition in August 2019 saw the team from the [Technical University of Munich](https://en.wikipedia.org/wiki/Technical_University_of_Munich), now known as TUM Hyperloop (by NEXT Prototypes e.V.),[[41]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:5-41) again winning the competition and beating their own record with a top speed of 463 km/h (288 mph).[[34]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:0-34)

The first passenger test of Hyperloop technology was successfully conducted by Virgin Hyperloop with two employees of the company in November 2020.[[42]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-42)

## Theory and operation

[Une image contenant texte

Description générée automatiquement](https://en.wikipedia.org/wiki/File:Hyperloop_capsule.svg)

Artist's impression of a Hyperloop capsule: [Axial compressor](https://en.wikipedia.org/wiki/Axial_compressor) on the front, passenger compartment in the middle, battery compartment at the back, and [air caster](https://en.wikipedia.org/wiki/Air_caster) skis at the bottom

[Une image contenant texte, meubles, table, table de travail

Description générée automatiquement](https://en.wikipedia.org/wiki/File:Hyperloop.jpg)

A 3D sketch of potential Hyperloop infrastructure. The steel tubes are rendered transparent in this image.

Developments in [high-speed rail](https://en.wikipedia.org/wiki/High-speed_rail) have historically been impeded by the difficulties in managing [friction](https://en.wikipedia.org/wiki/Friction) and [air resistance](https://en.wikipedia.org/wiki/Air_resistance),[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)] both of which become substantial when vehicles approach high speeds. The [vactrain](https://en.wikipedia.org/wiki/Vactrain) concept theoretically eliminates these obstacles by employing [magnetically levitating](https://en.wikipedia.org/wiki/Maglev) trains in [evacuated](https://en.wikipedia.org/wiki/Vacuum) (airless) or partly evacuated tubes, allowing for speeds of thousands of kilometers per hour. However, the high cost of [maglev](https://en.wikipedia.org/wiki/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 one [millibar](https://en.wikipedia.org/wiki/Bar_(unit)) (100 [Pa](https://en.wikipedia.org/wiki/Pascal_(unit))) of pressure.[[43]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-nova20130813-43)

### Initial design concept

The Hyperloop concept operates by sending specially designed "capsules" or "pods" through a steel tube maintained at a partial vacuum. In Musk's original concept, each capsule would float on a 0.02–0.05 in (0.5–1.3 mm) layer of air provided under pressure to [air-caster](https://en.wikipedia.org/wiki/Air_caster) "skis", similar to how pucks are levitated above an [air hockey](https://en.wikipedia.org/wiki/Air_hockey) table, while still allowing higher speeds than wheels can sustain. With [rolling resistance](https://en.wikipedia.org/wiki/Rolling_resistance) eliminated and air resistance greatly reduced, the capsules can [glide](https://en.wikipedia.org/wiki/Gliding_flight) for the bulk of the journey. In the alpha design concept, an electrically driven [inlet fan](https://en.wikipedia.org/wiki/Ducted_fan) and [axial compressor](https://en.wikipedia.org/wiki/Axial_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. A fraction of the air was to be shunted to the skis for additional pressure, augmenting that gain passively from lift due to their shape.[[7]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-AlphaSpaceX-7)

In the alpha-level concept, passenger-only pods were to be 7 ft 4 in (2.23 m) in diameter and were projected to reach a top speed of 760 mph (1,220 km/h) to maintain aerodynamic efficiency.[[7]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-AlphaSpaceX-7) (Section 4.4) The design proposed passengers experience a maximum inertial [acceleration](https://en.wikipedia.org/wiki/G-force) of 0.5 g, about 2 or 3 times that of a commercial airliner on takeoff and landing.[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)]

### Proposed routes

[Une image contenant carte

Description générée automatiquement](https://en.wikipedia.org/wiki/File:Interstate5_map.png)

Interstate 5

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 (distances of under approximately 1,500 kilometres (930 miles)).[[3]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:7-3) Route *proposals* range from speculation described in company releases to [business cases](https://en.wikipedia.org/wiki/Business_case) to signed agreements.

### Open-source design evolution

In September 2013, [Ansys](https://en.wikipedia.org/wiki/Ansys) Corporation ran [computational fluid dynamics](https://en.wikipedia.org/wiki/Computational_fluid_dynamics) simulations to model the aerodynamics of the capsule and [shear stress](https://en.wikipedia.org/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](https://en.wikipedia.org/wiki/Supersonic) airflow, and that the gap between the tube wall and capsule would need to be larger. Ansys employee Sandeep Sovani said the simulation showed that Hyperloop has challenges but that he is convinced it is feasible.[[83]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-Discovery-83)[[84]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-CNet-84)

In October 2013, the development team of the [OpenMDAO](https://en.wikipedia.org/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 13 feet (4 m) in diameter,[[85]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-openmdao-85) 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 technical factors required to physically construct a Hyperloop based on Musk's concept, and in particular had no significant estimations of component weight.[[86]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-github-mdao-86)

In November 2013, [MathWorks](https://en.wikipedia.org/wiki/MathWorks) analyzed the proposal's suggested route and concluded that the route was mainly feasible. The analysis focused on the [acceleration](https://en.wikipedia.org/wiki/G-force) 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.[[87]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-mathworks20131122-87)

In January 2015, a paper based on the NASA OpenMDAO open-source model reiterated the need for a larger diameter tube and a reduced cruise speed closer to Mach 0.85. It recommended removing on-board heat exchangers based on thermal models of 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 30–40 °F (17–22 °C) above ambient temperature.[[88]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-Chin2015-88)

According to Musk, various aspects of the Hyperloop have technology applications to other Musk interests, including [surface transportation on Mars](https://en.wikipedia.org/wiki/Surface_transportation_on_Mars) and electric jet propulsion.[[89]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-fortune20160131-89)[[90]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-musk20160130-90)

Researchers associated with MIT's department of Aeronautics and Astronautics published research in June 2017 that verified the challenge of [aerodynamic](https://en.wikipedia.org/wiki/Aerodynamic) design near the [Kantrowitz limit](https://en.wikipedia.org/wiki/Kantrowitz_limit) that had been theorized in the original SpaceX Alpha-design concept released in 2013.[[91]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-91)

In 2017, [Dr. Richard Geddes](https://en.wikipedia.org/wiki/Richard_Geddes_(academic)) and others formed the Hyperloop Advanced Research Partnership to act as a clearinghouse of Hyperloop public domain reports and data.[[92]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-92)

In February 2020, Hardt Hyperloop, Hyper Poland, TransPod and Zeleros formed a consortium to drive standardisation efforts, as part of a joint technical committee (JTC20) set up by European standards bodies [CEN](https://en.wikipedia.org/wiki/European_Committee_for_Standardization) and [CENELEC](https://en.wikipedia.org/wiki/European_Committee_for_Electrotechnical_Standardization) to develop common standards aimed at ensuring the safety and interoperability of infrastructure, rolling stock, signalling and other systems.[[93]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-93)

### Mars

According to Musk, Hyperloop would be useful on Mars as no tubes would be needed because Mars' atmosphere is about 1% the density of the Earth's at sea level.[[94]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-94)[[18]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-youtube20160131-18)[[95]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-conversation20150713-95)[[96]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-96) 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. This type of transportation infrastructure is commonly referred to as a [train](https://en.wikipedia.org/wiki/Train).[[97]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-97)

## Hyperloop companies

### Virgin Hyperloop

Main article: [Virgin Hyperloop](https://en.wikipedia.org/wiki/Virgin_Hyperloop)

Virgin Hyperloop (formerly Hyperloop One, Virgin Hyperloop One, and before that, Hyperloop Technologies)[[98]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-98)[[99]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-99) was incorporated in 2014 and has built a team of 280+,[[*when?*](https://en.wikipedia.org/wiki/Wikipedia:Manual_of_Style/Dates_and_numbers#Chronological_items)] including engineers, technicians, welders, and machinists. It has raised more than US$160 million in capital from investors including [DP World](https://en.wikipedia.org/wiki/DP_World), [Sherpa Capital](https://en.wikipedia.org/wiki/Sherpa_Capital), [Formation 8](https://en.wikipedia.org/wiki/Formation_8), 137 Ventures, Caspian Venture Capital, Fast Digital, GE Ventures, and [SNCF](https://en.wikipedia.org/wiki/SNCF).[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)]

Hyperloop One was founded by [Shervin Pishevar](https://en.wikipedia.org/wiki/Shervin_Pishevar) and Brogan BamBrogan.[[100]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-100) BamBrogan left the company in July 2016,[[101]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-101) along with three of the other founding members of [Arrivo](https://en.wikipedia.org/wiki/Arrivo).[[102]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-102) Hyperloop One then selected co-founder Josh Giegel, a former SpaceX engineer, to be CTO;[[103]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-103) Giegel now serves as CEO.[[104]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-104)

Hyperloop One has a 75,000-square foot Innovation Campus in downtown LA and a 100,000-square foot machine and tooling shop in North Las Vegas. By 2017, it had completed a 500m Development Loop (DevLoop) in North Las Vegas, Nevada.[[105]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-105)

On 11 May 2016, Hyperloop One conducted the first live trial of Hyperloop technology, demonstrating that its custom linear electric motor could propel a sled from 0 to 110 miles an hour in just over one second.[[106]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-106) The [acceleration](https://en.wikipedia.org/wiki/G-force) exerted approximately 2.5 g on the sled. The sled was stopped at the end of the test by hitting a pile of sand at the end of the track, because the test was not intended to test braking components.[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)]

In July 2016, Hyperloop One released a preliminary study that suggested a Hyperloop connection between [Helsinki](https://en.wikipedia.org/wiki/Helsinki) and [Stockholm](https://en.wikipedia.org/wiki/Stockholm) would be feasible, reducing the travel time between the cities to half an hour. The construction costs were estimated by Hyperloop One to be around €19 billion (US$21 billion at 2016 exchange rates).[[107]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-helsinki-verge-107)

In August 2016, Hyperloop One announced a deal with the world's third largest ports operator, DP World, to develop a cargo offloader system at DP World's flagship port of Jebel Ali in Dubai.[[108]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-108) Hyperloop One also broke ground on DevLoop, its full-scale Hyperloop test track.

In November 2016, Hyperloop One disclosed that it has established a high-level working group relationship with the governments of Finland and the Netherlands to study the viability of building Hyperloop proof of operations centers in those countries. Hyperloop One also has a feasibility study underway with Dubai's Roads and Transport Authority for passenger systems in the UAE.[[109]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-109) Other feasibility studies are underway in Russia, Los Angeles, and the Netherlands.

On 12 May 2017, Hyperloop One performed its first full-scale Hyperloop test, becoming the first company in the world to test a full-scale Hyperloop.[[110]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-110) The system-wide test integrated Hyperloop components including vacuum, propulsion, levitation, sled, control systems, tube, and structures.

On 12 July 2017, the company revealed images of its first-generation pod prototype, which will be used at the DevLoop test site in Nevada to test aerodynamics.[[111]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-111)

On 12 October 2017, the company received a "significant investment" from the Virgin Group founder Richard Branson, leading to a rebrand of the name.[[112]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-112)

In February 2018, Richard Branson of Virgin Hyperloop One announced that he had a preliminary agreement with the [Maharashtra](https://en.wikipedia.org/wiki/Maharashtra) State government of [India](https://en.wikipedia.org/wiki/India) to build the Mumbai-Pune Hyperloop.[[113]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-113)

In 2019, a partnership was formed between Virgin Hyperloop One, the University of Missouri, and engineering firm [Black & Veatch](https://en.wikipedia.org/wiki/Black_%26_Veatch) to investigate a Missouri Hyperloop .[[52]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-Missouri_feasibility_study-52)[[53]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-Missouri_move_forward-53)

In March 2019, Missouri governor [Mike Parson](https://en.wikipedia.org/wiki/Mike_Parson) announced the creation of a "Blue Ribbon" panel to examine the specifics of funding and construction of the [Missouri Hyperloop](https://en.wikipedia.org/wiki/Missouri_Hyperloop).[[114]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-114) The route would connect Missouri's largest cites including [St. Louis](https://en.wikipedia.org/wiki/St._Louis), [Kansas City](https://en.wikipedia.org/wiki/Kansas_City,_Missouri), and [Columbia](https://en.wikipedia.org/wiki/Columbia,_Missouri).[[115]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-115) This comes after a 2018 feasibility study found the route viable, the first such study in the United States.[[116]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-116)

In June 2019, a partnership with the [Sam Fox School](https://en.wikipedia.org/wiki/Sam_Fox_School_of_Design_%26_Visual_Arts) of [Washington University of St. Louis](https://en.wikipedia.org/wiki/Washington_University_in_St._Louis) was announced to further investigate different proposals for the Missouri Hyperloop.[[117]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-117)

In July 2019, the Government of Maharashtra State of India and Hyperloop One set a target to create the first hyperloop system in the world between Pune and Mumbai.[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)]

In November 2020, Company co-founder Josh Giegel and head of Passenger Experience Sara Luchian were part of the first crewed Hyperloop trip on the company's DevLoop in Nevada, reaching a speed of 172 km/h (107 mph).[[118]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-118)

### Hyperloop Transportation Technologies

Main article: [Hyperloop Transportation Technologies](https://en.wikipedia.org/wiki/Hyperloop_Transportation_Technologies)

Hyperloop Transportation Technologies (HTT) is the first Hyperloop company created (founded in 2013), with a current workforce of more than 800 engineers and professionals located around the world.[[119]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-119) Some collaborate part-time; others are full-time employees and contributors. Some members are full-time paid employees; others work in exchange for salary and [stock options](https://en.wikipedia.org/wiki/Stock_option).[[120]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-120)

After Musk's Hyperloop concept proposal in 2012, Jumpstarter, Inc founder Dirk Ahlborn placed a 'call to action' on his Jumpstarter platform.[[121]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-tech.eu-121) Jumpstarter started pooling resources and amassed 420 people to the team.[[121]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-tech.eu-121)

HTT announced in May 2015 that a deal had been finalized with landowners to build a 5-mile (8 km) test track along a stretch of road near [Interstate 5](https://en.wikipedia.org/wiki/Interstate_5_in_California) between Los Angeles and San Francisco.[[122]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-fortune20150520-122) In December 2016, Hyperloop Transportation Technologies and the government of [Abu Dhabi](https://en.wikipedia.org/wiki/Abu_Dhabi) announced plans to conduct a feasibility study on a Hyperloop link between the [UAE](https://en.wikipedia.org/wiki/UAE) capital and [Al Ain](https://en.wikipedia.org/wiki/Al_Ain), reducing travel time between Abu Dhabi and Al Ain to just under 10-minutes.[[123]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-123) In September 2017, HTT announced and signed an agreement with the [Andhra Pradesh](https://en.wikipedia.org/wiki/Andhra_Pradesh) state government of India to build a track from [Amaravathi](https://en.wikipedia.org/wiki/Amaravathi) to [Vijayawada](https://en.wikipedia.org/wiki/Vijayawada) in a [public-private partnership](https://en.wikipedia.org/wiki/Public-private_partnership), and suggested that the more than one hour trip could be reduced to 5 minutes through the project.[[124]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-124)[[125]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-125) For yet undisclosed reason, neither the test track that HTT announced in May 2015 nor any other test track has been built in the last 3 years.

In June 2018, Ukraine's Infrastructure Ministry reached an agreement with Hyperloop Transportation Technologies to develop its high-speed vacuum transport technology in Ukraine.[[126]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-kyivpost.com-126) According to minister, Volodymyr Omelyan, a joint research and development center will be created in Kyiv or Dnipro, which will not only work on Hyperloop but new “materials and components for modern transportation systems.”[[126]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-kyivpost.com-126)

Later in 2018, the company signed an agreement with the Guizhou province of China to build a Hyperloop.[[127]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-auto-127) In its China deal, HTT will provide technology, engineering expertise, and essential equipment in the venture, while Tongren will take charge of relevant certifications, regulatory framework, and construction of the system, the press release said. The venture will be a public private partnership in which 50 percent of the funds will come directly from Tongren, it added.[[127]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-auto-127)

In May 2019, the company and TÜV SÜD presented the EU with generic guidelines for hyperloop design, operation and certification.[[128]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-128) In June 2019,Hyperloop Transportation Technologies met with officials from the United States Department of Transportation, USDOT, at HyperloopTT's research facilities in Toulouse, France.[[129]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-themeditelegraph.com-129) Simultaneously, other members of HyperloopTT met with the USDOT at the agency's offices in Washington D.C. presenting a technical overview of Hyperloop technology and the certification guideline completed by TÜV SÜD.[[129]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-themeditelegraph.com-129)

HyperloopTT is now beginning the process of integrating their full-scale passenger capsule for human trials in 2020.[[129]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-themeditelegraph.com-129)

### TransPod

Main article: [TransPod](https://en.wikipedia.org/wiki/TransPod)

[TransPod](https://en.wikipedia.org/wiki/TransPod) Inc. is a Canadian company designing and manufacturing ultra-high-speed tube transportation technology and vehicles.[[130]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-transpodabout-130) In November 2016 TransPod raised a US$15 million seed round from Angelo Investments, an Italian high-tech holding group, specializing in advanced technologies for the railway, space, and aviation industries.[[131]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-techvibes15-131)

In September 2017, TransPod released a scientific peer-reviewed publication in the journal Procedia Engineering.[[132]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-scidirect-132) The paper was premiered at the [EASD](https://en.wikipedia.org/wiki/European_Association_for_Structural_Dynamics) EURODYN 2017 conference,[[133]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-eurodynlectures-133) and presents the physics of the TransPod system.[[134]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-procedia-134)

TransPod vehicles are being designed to travel at over 1,000 km/h between cities using fully electric propulsion and zero need for fossil fuels.[[134]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-procedia-134) The TransPod tube system is distinct from the hyperloop concept proposed by Elon Musk's Hyperloop Alpha white paper. The TransPod system uses moving electromagnetic fields to propel the vehicles with stable levitation off the bottom surface, rather than compressed air.[[134]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-procedia-134) TransPod is stated to contain further developments beyond hyperloop.[[135]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-tedxtoronto-135)[[136]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-betakit20-136) To achieve fossil-fuel-free propulsion, TransPod "pods" take advantage of electrically driven [linear induction motor](https://en.wikipedia.org/wiki/Linear_induction_motor) technology, with active real-time control[[134]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-procedia-134) and sense-space systems.[[137]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-sensespace-137) The cargo transport TransPod pods will be able to carry payloads of 10–15 tons and have compatibility with wooden pallets, as well as various [unit load devices](https://en.wikipedia.org/wiki/Unit_load_device) such as LD3 containers, and AAA containers.[[138]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-parisairforum-138)

At the [InnoTrans](https://en.wikipedia.org/wiki/InnoTrans) Rail Show 2016 in Berlin, TransPod premiered their vehicle concept, alongside implementation of Coelux technology—an artificial [skylight](https://en.wikipedia.org/wiki/Skylight) to emulate natural sunlight within the passenger pods.[[139]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-wired-139)[[140]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-itberlin-140)

TransPod has partnered with investor Angelo Investments' member companies [MERMEC](https://en.wikipedia.org/wiki/MERMEC), SITAEL, and Blackshape Aircraft. With international staff of over 1,000 employees, 650 of whom are engineers, they will collaborate with the development and testing of the TransPod tube system[[141]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-mermecjoins-141)[[142]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-sitaeljoins-142)[[131]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-techvibes15-131) It has since expanded from its Toronto, Canada headquarters at [MaRS Discovery District](https://en.wikipedia.org/wiki/MaRS_Discovery_District)[[143]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-143)[[144]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-masstransitthree-144) to open offices in Toulouse, France and Bari, Italy.[[145]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-blackshapeglobal-145)[[146]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-inversethree-146) TransPod is additionally partnered with university researchers, engineering firm IKOS,[[147]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-ikos-147) REC Architecture and [Liebherr-Aerospace](https://en.wikipedia.org/wiki/Liebherr_Group).[[148]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-liebherr-148)[[149]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-149)[[150]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-150)

TransPod is developing routes worldwide and in Canada such as Toronto-Montreal,[[151]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-torontoStar_transpod-151)[[73]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-Rapid_Transit-73)[[152]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-152) Toronto-Windsor,[[74]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-Daily_Hive-74) and Calgary-Edmonton.[[75]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-cbccalgarycorridor-75) TransPod is preparing to build a test track for the pod vehicles in Canada.[[153]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-153) This track will be extendable as part of a full route pending a combination of private and public funding to construct the line.[[75]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-cbccalgarycorridor-75)

In July 2017, TransPod released an initial cost study[[154]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-magnitudeanalysis-154) which outlines the viability of building a hyperloop line in Southwestern Ontario between the cities of Windsor and Toronto.[[155]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-hypetechvibes-155) The study indicates a TransPod tube system would cost half the projected cost of a high-speed rail line along the same route, while operating at more than four times the top speed of high speed rail.[[154]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-magnitudeanalysis-154)

TransPod has announced plans for a test track to be constructed in the town of [Droux](https://en.wikipedia.org/wiki/Droux) near [Limoges](https://en.wikipedia.org/wiki/Limoges)[[156]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-156) in collaboration with the French department of [Haute-Vienne](https://en.wikipedia.org/wiki/Haute-Vienne). The proposed test track would exceed 3 km in length, and operate as a half-scale system 2 m in diameter.[[157]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-lelpopulaire-157)[[158]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-158)[[159]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-159) In February 2018 Vincent Leonie, vice president of [Limoges Métropole](https://en.wikipedia.org/wiki/Communaut%C3%A9_d%27agglom%C3%A9ration_Limoges_M%C3%A9tropole) and a deputy mayor of Limoges,[[160]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-limogesmetropole-160) has announced agreements for the "Hyperloop Limoges" organization have been signed to promote and accelerate the technology.[[157]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-lelpopulaire-157)

### DGWHyperloop

Established in 2015, DGWHyperloop is a subsidiary of Dinclix GroundWorks, an engineering company based in [Indore](https://en.wikipedia.org/wiki/Indore), India.[[161]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-161) DGWHyperloop's initial proposals include a Hyperloop-based corridor between [Delhi](https://en.wikipedia.org/wiki/Delhi) and Mumbai called the Delhi Mumbai Hyperloop Corridor (DMHC).[[162]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-162)[[163]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-163) The company has partnered with many government agencies, private companies, and institutions for its research on Hyperloop.[[164]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-164) DGWHyperloop is the only Indian company working on implementing the Hyperloop system across the nation.[[165]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-165)[[166]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-166)[[167]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-167)

### Arrivo

[Arrivo](https://en.wikipedia.org/wiki/Arrivo) was a technology architecture and engineering company founded in Los Angeles in 2016. In November 2017, it disclosed a plan to build a 200 mph (320 km/h) link for automobiles to [Denver International Airport](https://en.wikipedia.org/wiki/Denver_International_Airport) using [maglev](https://en.wikipedia.org/wiki/Maglev) train technology by 2021.[[50]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-fm171114-50) On 14 December 2018 Technology news site The Verge reported Arrivo was shutting down, due to being unable to secure Series A funding.[[168]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-168)

On 17 October 2019, The Verge reported the Intellectual Property from Arrivo was purchased by rLoop, a reddit-born engineering group.[[169]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-169)

### Hardt Global Mobility

Hardt Global Mobility[[170]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-170) was founded in 2016 in [Delft](https://en.wikipedia.org/wiki/Delft), emerging from the [TU Delft](https://en.wikipedia.org/wiki/TU_Delft) Hyperloop team who won at the [Hyperloop pod competition](https://en.wikipedia.org/wiki/Hyperloop_pod_competition).[[33]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-Delft-NLTimes-2017-01-30-33)

The Dutch team is setting up a full-scale testing center for hyperloop technology in Delft. Hardt has received over €600,000 in funding for the initial rounds of testing, with plans to raise more to build a high-speed test line by 2019.[[171]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-171) At the unveiling of the test track, Dutch Minister of Infrastructure and Environment [Schultz van Haegen](https://en.wikipedia.org/wiki/Melanie_Schultz_van_Haegen) said a Hyperloop system could help cement the Netherlands' position as a gateway to Europe by transporting freight arriving at Rotterdam's sprawling port.[[172]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-172)

On 9 October 2017 a report was released with information from Hardt Global Mobility and Hyperloop One. The report has been sent to the [Dutch House of Representatives](https://en.wikipedia.org/wiki/House_of_Representatives_(Netherlands)) and judges the added value of a hyperloop test track facility. The report recommends building a test track of 5 km in [Flevoland](https://en.wikipedia.org/wiki/Flevoland).[[173]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-173)

### Zeleros

Zeleros[[174]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-174)[[175]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-175) was founded in [Valencia](https://en.wikipedia.org/wiki/Valencia) (Spain) in November 2016 by Daniel Orient (CTO), David Pistoni (CEO) and Juan Vicén (CMO), former leaders of the [Hyperloop UPV](https://en.wikipedia.org/wiki/Hyperloop_UPV) team from [Universitat Politècnica de València](https://en.wikipedia.org/wiki/Technical_University_of_Valencia). The team was awarded "Top Design Concept" and "Propulsion/Compression Subsystem Technical Excellence" at [SpaceX](https://en.wikipedia.org/wiki/SpaceX)'s Hyperloop Design Weekend, the first phase of the [Hyperloop Pod Competition](https://en.wikipedia.org/wiki/Hyperloop_pod_competition) conducted at [Texas A&M University](https://en.wikipedia.org/wiki/Texas_A%26M_University) on 29–30 January 2016.[[176]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-176) After building Spain's first Hyperloop prototype with the support of Purdue University[[177]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-177) and building a 12-meter research test-track in Spain[[178]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-178) at the university, the company was awarded in November 2017 the international Everis Foundation prize.[[179]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-179) Zeleros has the support of the Silicon Valley accelerator [Plug and Play Tech Center](https://en.wikipedia.org/wiki/Plug_and_Play_Tech_Center),[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)] its partner Alberto Gutierrez, (partner of Plug and Play Spain and founder of Aqua Service), and the Spanish venture capital fund Angels Capital[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)] owned by the Spanish businessman [Juan Roig](https://en.wikipedia.org/wiki/Juan_Roig), owner of [Mercadona](https://en.wikipedia.org/wiki/Mercadona). By June 2018, the corporation signed an agreement with the rest of the Hyperloop European companies (Hyper Poland and Hardt) and the Canadian [TransPod](https://en.wikipedia.org/wiki/TransPod) to collaborate with the European Union and other international institutions for the implementation of a definition of the standards to ensure the interoperability and the security of a Hyperloop. In August 2018, Zeleros held a meeting with [Pedro Duque](https://en.wikipedia.org/wiki/Pedro_Duque), the ministry of science[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)] to push for his support of the European initiative. By September 2018, the corporation announced the construction of a 2 km test track to perform dynamic tests of the system. The test track will be allocated in [Sagunto](https://en.wikipedia.org/wiki/Sagunto) in 2019 with the support of the Sagunto council and the [Generalitat Valenciana](https://en.wikipedia.org/wiki/Generalitat_Valenciana).[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)] In November 2018, Zeleros received the international award in the World Transport Congress in Mascate, [Omán](https://en.wikipedia.org/wiki/Oman).[[180]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-180) By February 2019, the corporation was formed by a team of 20 engineers and doctors specialized in different fields, developing and testing the systems and subsystems of the Hyperloop integrators.

In June 2020 Zeleros raised more than €7 million in financing, with plans to use them in the development of its core technologies, the construction of a European Hyperloop Development Centre in Spain and building a 3 km test track.[[181]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-181)

Their designs are said to incorporate an on-board [maglev](https://en.wikipedia.org/wiki/Maglev) levitation and [linear electric motor](https://en.wikipedia.org/wiki/Linear_electric_motor) propulsion rather than in-track inductors coupled with [pneumatic tube](https://en.wikipedia.org/wiki/Pneumatic_tube) thrust motors, together allegedly capable of achieving one thousand Km/h (≈620 MPH). The ultimate intention is to combine both [intermodal container](https://en.wikipedia.org/wiki/Intermodal_container) and passenger compartments that will exploit [advanced aircraft technology](https://en.wikipedia.org/wiki/Supersonic_transport#Aerodynamics).[[182]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-182)

### Nevomo (previously Hyper Poland)

Nevomo (until November 2020 *Hyper Poland*)[[71]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-itkey20160217-71) is a Polish company founded in 2017 by Przemysław Pączek, Katarzyna Foljanty, Paweł Radziszewski and Łukasz Mielczarek, mostly graduates from the [Warsaw University of Technology](https://en.wikipedia.org/wiki/Warsaw_University_of_Technology). In the summer of 2017, acting as the *Hyper Poland University Team*, they built a hyperloop vehicle model which took part in the SpaceX Pod Competition II in California. In March 2018, the company was recognized as one of the best startups in the mobility sector in Europe.[[183]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-183)

Unlike other companies in the Hyperloop sector, Nevomo develops a system aimed at offering a low-cost upgrade to existing conventional railway corridors. The system - dubbed ‘magrail’ - is based on magnetic levitation, linear motor and autonomous control systems and can be transformed into a full-fledged, vacuum Hyperloop at a later stage.[[184]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-184)

Key differentiator of Nevomo's magrail technology is its interoperability with conventional railway systems which allows for the functionality of both the magrail system and conventional trains on the same tracks and promises reduced infrastructure costs and faster implementation by using existing and regulatorily approved railway corridors. In its initial implementation stage, the system is designed for speeds comparable to today's conventional [high-speed rail](https://en.wikipedia.org/wiki/High-speed_rail) (300–415 km/h), but at significantly lower implementation costs. The system allows a subsequent upgrade into a vacuum system with speeds of up to 600 km/h on conventional tracks and 1,000 km/h on HSR lines.[[185]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-185)

In the first half of 2019, Nevomo secured a EUR 3.8 million grant from the Polish National Center for Research and Development[[186]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-186) and two pre-seed rounds on a UK equity crowdfunding platform of EUR 820k total.[[187]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-187)

In October 2019, Nevomo presented its 'magrail' prototype vehicle and a track in 1:5 scale. Nevomo has completed the first magrail tests on a medium-sized track and plans to start full-scale tests in mid-2021.[[188]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-188)

In June 2021 Nevomo signed a [memorandum of understanding](https://en.wikipedia.org/wiki/Memorandum_of_understanding) with [Rete Ferroviaria Italiana](https://en.wikipedia.org/wiki/Rete_Ferroviaria_Italiana) (RFI) to collaborate on studies to verify the technical and economic feasibility of superposing magrail technology. The two firms will apply to the [European Union](https://en.wikipedia.org/wiki/European_Union) for funding to built a full-scale system pilot on a test track at the [Bologna San Donato railway test circuit](https://en.wikipedia.org/wiki/Bologna_San_Donato_railway_test_circuit), which is owned by RFI.[[189]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-189)

## Hyperloop pod competition

Main article: [Hyperloop pod competition](https://en.wikipedia.org/wiki/Hyperloop_pod_competition)

[Une image contenant texte, extérieur, missile, fusée

Description générée automatiquement](https://en.wikipedia.org/wiki/File:Hyperloop_pod_competition_tube.jpg)

Hyperloop pod competition

A number of student and non-student teams were participating in a [Hyperloop pod competition](https://en.wikipedia.org/wiki/Hyperloop_pod_competition) in 2015–16, and at least 22 of them built hardware to compete on a sponsored hyperloop test track in mid-2016.[[194]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-verge20160130-194)

In June 2015, SpaceX announced that they would sponsor a Hyperloop pod design competition, and would build a 1-mile-long (1.6 km) subscale test track near SpaceX's headquarters in [Hawthorne, California](https://en.wikipedia.org/wiki/Hawthorne,_California), for the competitive event in 2016.[[195]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-NBChyperloop-195)[[196]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-hyper-pod-competition-196) 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."[[197]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-spacexhyperloop-197)

More than 700 teams had submitted preliminary applications by July,[[198]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-binsider20150623-198) and detailed competition rules were released in August.[[199]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-rules_v20-199) *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, where more than 120 student engineering teams were selected to submit *Final Design Packages* due by 13 January 2016.[[200]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-gw20151215-200)

A *Design Weekend* was held at [Texas A&M University](https://en.wikipedia.org/wiki/Texas_A%26M_University) 29–30 January 2016, for all invited entrants.[[201]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-tamu201510-201) Engineers from the [Massachusetts Institute of Technology](https://en.wikipedia.org/wiki/Massachusetts_Institute_of_Technology) were named the winners of the competition. While the [University of Washington](https://en.wikipedia.org/wiki/University_of_Washington) team won the Safety Subsystem Award, [Delft University](https://en.wikipedia.org/wiki/Delft_University) won the Pod Innovation Award[[202]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-202) as well as the second place, followed by the [University of Wisconsin–Madison](https://en.wikipedia.org/wiki/University_of_Wisconsin%E2%80%93Madison), [Virginia Tech](https://en.wikipedia.org/wiki/Virginia_Tech), and the [University of California, Irvine](https://en.wikipedia.org/wiki/University_of_California,_Irvine).[[194]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-verge20160130-194)[[203]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-203) In the Design Category, the winner team was [Hyperloop UPV](https://en.wikipedia.org/wiki/Hyperloop_UPV) from Universitat Politecnica de Valencia, Spain.[[204]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-204) On 29 January 2017, Delft Hyperloop (Delft University of Technology) won the prize for the "best overall design" at the final stage of the SpaceX Hyperloop competition,[[205]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-205) while WARR Hyperloop of the [Technical University of Munich](https://en.wikipedia.org/wiki/Technical_University_of_Munich) won the prize for "fastest pod".[[34]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:0-34) The Massachusetts Institute of Technology placed third.[[206]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-206)

The second Hyperloop pod competition took place from 25–27 August 2017. The only judging criteria being top speed provided it is followed by successful deceleration. WARR Hyperloop from the Technical University of Munich won the competition by reaching a top speed of 324 km/h (201 mph).[[37]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:1-37)[[38]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:2-38)[[39]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:3-39)

A third Hyperloop pod competition took place in July 2018. The defending champions, the WARR Hyperloop team from the Technical University of Munich, beat their own record with a top speed of 457 km/h (284 mph) during their run.[[40]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:4-40) The fourth competition in August 2019 saw the team from the Technical University of Munich, now known as TUM Hyperloop (by NEXT Prototypes e.V.),[[41]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:5-41) again winning the competition and beating their own record with a top speed of 463 km/h (288 mph).[[34]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-:0-34)

## Criticism and human factor considerations

Some critics of Hyperloop focus on the experience—possibly unpleasant and frightening—of riding in a narrow, sealed, windowless capsule inside a sealed steel tunnel, that is subjected to significant [acceleration forces](https://en.wikipedia.org/wiki/G-force); high noise levels due to air being compressed and ducted around the capsule at near-sonic speeds; and the vibration and jostling.[[207]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-insider20130820-207) Even if the tube is initially smooth, ground may shift with seismic activity. At high speeds, even minor deviations from a straight path may add considerable [buffeting](https://en.wikipedia.org/wiki/Buffeting).[[208]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-verge20130816-208) This is in addition to practical and logistical questions regarding how to best deal with safety issues such as equipment malfunction, accidents, and emergency evacuations.

Other [maglev](https://en.wikipedia.org/wiki/Maglev) trains are already in use, which avoid much of the added costs of Hyperloop. The [SCMaglev](https://en.wikipedia.org/wiki/SCMaglev)[[209]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-209) in Japan has demonstrated 603 km/h (375 mph) without a vacuum tube, by using an extremely aerodynamic train design. It also avoids the cost and time required to pressurize and depressurize the exit and entry points of a Hyperloop tube.

There is also the criticism of design technicalities in the tube system. John Hansman, professor of aeronautics and astronautics at [MIT](https://en.wikipedia.org/wiki/Massachusetts_Institute_of_Technology), has stated problems, such as how a slight misalignment in the tube would be compensated for and the potential interplay between the air cushion and the low-pressure air. He has also questioned what would happen if the power were to go out when the pod was miles away from a city. [UC Berkeley](https://en.wikipedia.org/wiki/University_of_California,_Berkeley) physics professor Richard Muller has also expressed concern regarding "[the Hyperloop's] novelty and the vulnerability of its tubes, [which] would be a tempting target for terrorists", and that the system could be disrupted by everyday dirt and grime.[[210]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-Mercury-2016-09-16-210)

## Political and economic considerations

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](https://en.wikipedia.org/wiki/Interstate_5_in_California). 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](https://en.wikipedia.org/wiki/Right-of-way) opposition and environmental impact as well due to its small, sealed, elevated profile versus that of a rail easement;[[7]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-AlphaSpaceX-7) however, other commentators contend that a smaller footprint does not guarantee less opposition.[[44]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-GGW-44) In criticizing this assumption, [mass transportation](https://en.wikipedia.org/wiki/Mass_transportation) writer Alon Levy said, "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".[[211]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-NationalReview-211)[[212]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-WaPoWonkBlog-212) Michael Anderson, a professor of agricultural and resource economics at [UC Berkeley](https://en.wikipedia.org/wiki/UC_Berkeley), predicted that costs would amount to around US$100 billion.[[9]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-AJE-9)

The Hyperloop white paper suggests that US$20 of each one-way passenger ticket between Los Angeles and San Francisco would be sufficient to cover initial [capital costs](https://en.wikipedia.org/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](https://en.wikipedia.org/wiki/Fare) was suggested in the alpha design.[[7]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-AlphaSpaceX-7) The projected ticket price has been questioned by Dan Sperling, director of the [Institute of Transportation Studies](https://en.wikipedia.org/wiki/Institute_of_Transportation_Studies) at [UC Davis](https://en.wikipedia.org/wiki/UC_Davis), who stated that "there's no way the economics on that would ever work out."[[9]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-AJE-9) However, some critics have argued that, being designed to carry fewer passengers than typical public train systems, it could make it difficult to price tickets to cover the costs of construction and running.[[213]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-213)

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 US$6 billion price tag dramatically understates the cost of designing, developing, constructing, and testing an all-new form of transportation.[[8]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-NYT-Bilton-8)[[9]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-AJE-9)[[44]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-GGW-44)[[212]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-WaPoWonkBlog-212) *The Economist* said that the estimates are unlikely to "be immune to the [hypertrophication of cost](https://en.wikipedia.org/wiki/Cost_overrun) that every other grand infrastructure project seems doomed to suffer."[[16]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-economist20130817-16)

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](https://en.wikipedia.org/wiki/Reputation_capital)" invested in the existing mega-project of [California High-Speed Rail](https://en.wikipedia.org/wiki/California_High-Speed_Rail).[[16]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-economist20130817-16) 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.[[16]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-economist20130817-16)

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.[[20]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-gm20130813-20)[[16]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-economist20130817-16)

The solar panels Musk plans to install along the length of the Hyperloop system have been criticized by engineering professor Roger Goodall of [Loughborough University](https://en.wikipedia.org/wiki/Loughborough_University), as not being feasible enough to return enough energy to power the Hyperloop system, arguing that the air pumps and propulsion would require much more power than the solar panels could generate.[[210]](https://en.wikipedia.org/wiki/Hyperloop#cite_note-Mercury-2016-09-16-210)