Report

Roland Berger

Mobility revolution or pipe dream?

HYPERLOOP

Roland Berger

MANAGEMENT SUMMARY

Making the dream a reality

When will Hyperloop finally come of age?

Hyperloop represents a revolution in sustainable travel, offering high-speed transportation through its ingenious mixture of low-pressure environment and magnetic levitation. Its potential in terms of environmental friendliness, speed and convenience are unquestionable, its technical feasibility widely accepted. Why, then, after more than 200 years, has it still failed to find a major private or public backer? Why are we not yet traveling at almost the speed of sound, just above or just under the ground?

In this report we investigate the Hyperloop conundrum: why is a technology that seems to have everything going for it still struggling to achieve lift-off? What are its key advantages over existing means of transportation? What is delaying its development and implementation? And what should we be doing to turn the dream into a reality?

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1 / The Hyperloop conundrum

A promising technology that has so far failed to deliver

A decade on from the release of Elon Musk's Hyperloop Alpha document – a technical proposal for the design and development of a Hyperloop operating system, including details of pods, tube design, propulsion technology and routes – the Hyperloop industry appears to have made relatively little headway. No transportation corridor connecting two cities exists as yet, nor is there any Hyperloop test track longer than 500 meters. And on the test tracks that do exist today, the speeds being reached remain a long way off from the promised speed of sound. → A

The last decade has seen announcements of one Hyperloop study after another. Yet, nothing much appears to have happened beyond these studies. The engineers are diligently working away at proving technology readiness for Hyperloop, but this has not translated into actual applications. Indeed, our own Roland Berger studies have shown that the technology is viable – but still no one has taken the leap of faith required to turn the dream into a reality.

A REVOLUTIONARY TECHNOLOGY

On paper, Hyperloop has much to offer. In Hyperloop systems, pods travel through low-pressure tubes using electric propulsion and magnetic levitation. The tubes themselves are near vacuums to minimize air resistance, while magnetic levitation allows the pods to levitate, so avoiding friction. As a means of transportation it is revolutionary, it promises to be sustainable and extremely high-speed. → B

A / Thin on the ground

Existing Hyperloop test facilities

Las Vegas, USA: 500 m
Virgin Hyperloop One (VHO)

Toulouse, France: 320 m
Hyperloop Transportation Technologies (HTT)

Rotterdam, Netherlands: 30 m
Hardt Hyperloop*)

*) Hardt started construction of a new test track of 420 meters in 2023.

Source: Virgin Hyperloop One, Hyperloop Transportation Technologies, Hardt

B / What is Hyperloop?
Concept and value proposition

What is Hyperloop?
Hyperloop is a sustainable high-speed transport mode in which a pod travels through a low-pressure tube using electric propulsion and magnetic levitation

Key components of Hyperloop system

Pod
Vehicle to transfer **passengers** and/or freight

Tube
Protects system from environment

Vacuum system
Creates low-pressure in tube to **minimize air resistance**

Magnetic levitation
Allows **pods to levitate** and **avoid friction**

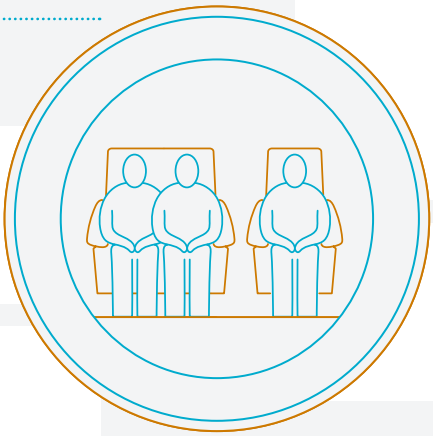
Propulsion
Linear motors are used to **propel pod forward**

Stations
To (dis)embark pods, maintaining pressure difference

Pod

Description
- A pod is a pressurized vehicle **transporting passengers and/or freight**
- Pods are **levitating** to leave out friction and decrease energy consumption

Main functions
- **Protect passengers and freight** from near-vacuum environment in the tube
- **Provide comfort** to passengers
- **Host the technologies** that are needed for other subsystems



Key aspects
- **Capacity** of a pod is between 25 and 60 passengers
- **Diameter** of a pod is ~3 meters
- **Speed** of up to ~1,200 km/h
- **Headway** between pods ranges from several seconds to 40 seconds, depending on the company

Current applications
- Exterior structure is similar to fuselage of an **aircraft**
- Interior design is similar to **trains, magLev** and **aircraft**

Superior proposition
vs. other transport modes, i.e. air, maglev, high-speed rail and road

Ultra-high speed[1)]

High throughput

High energy efficiency

High sustainability

[1)] Up to ~1,200 km/h (sub-sonic speed), with operational speeds envisioned at ~800 km/h due to efficiency reasons

Source: European Environment Agency, expert interviews, Hyperloop Transportation Technologies, Virgin Hyperloop One, Hardt, Roland Berger consortium analysis

Hyperloop offers a superior value proposition compared with many other modes of long-distance transportation. Air travel, for example, is a significant contributor to greenhouse gas emissions and climate change. Aircraft release CO_2, NO_x and other harmful emissions, as well as contrails, which also contribute to global warming. With passenger numbers now returning to pre-pandemic levels, we will soon see congested airports again, with limited runway and gate capacity, leading to delays and inefficiencies. Weather dependency, security concerns and a limited number of entry points (airports) also lead to long and sometimes hard-to-plan travel times.

Hyperloop offers a trio of great advantages: it's clean, it's convenient, and it's fast – very fast. With the growing focus on sustainability issues globally, the time seems right for the transportation sector to seriously consider a future with Hyperloop.

The situation regarding rail travel is not much better. Travel times for distances over 800 km are hardly acceptable, the system runs at high cost (infrastructure, rolling stock, energy consumption, especially for high-speed and cross-country operation), and seamless international traveling is hampered by incompatible ticketing systems and fare structures, making it challenging for passengers to book a single ticket for cross-border journeys.

At the same time, the global energy crisis and resulting increases in fuel prices are having a significant negative impact on car owners. As sustainability rises on the world's agenda and we see pandemic-induced shifts in travel preferences, we need to think twice before reverting to our old ways of travel. The time is right for bold innovation. Could Hyperloop be the way forward?

2/ Key advantages

Clean, quick and convenient

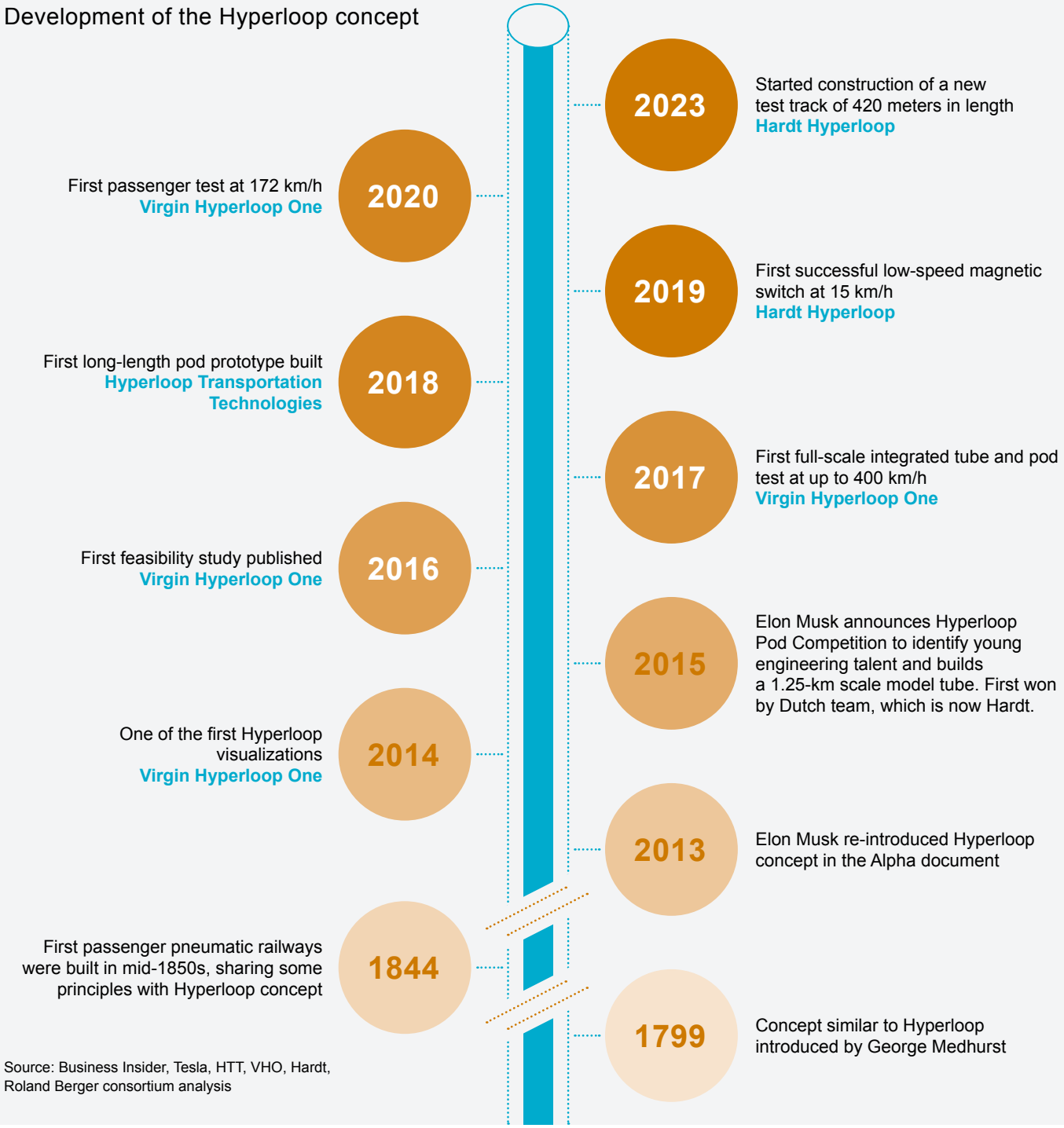
Hyperloop Alpha's proposal builds on a concept that dates back to the late 18th century. Since its very beginnings, the revolutionary mode of transportation has dangled the promise of clean, quick and convenient travel at superfast speeds before us – a dream that Musk successfully catapulted into the mainstream two centuries later. → C

A CLEAN FUTURE

Clean technologies are currently attracting huge investments as startups and corporates alike seek to make low-emission transportation a reality. Whether it is the aviation industry looking into sustainable fuels or the shift toward vehicle electrification on the roads, the direction of change is clear: the future will be carbon-neutral, or as close to carbon-neutral as possible.

C / It's been a long time coming

Development of the Hyperloop concept



Source: Business Insider, Tesla, HTT, VHO, Hardt, Roland Berger consortium analysis

Hyperloop promises to offer a far more attractive value proposition than the modes of transportation we see today. With friction all but eliminated, thanks to the lack of wheel-to-rail contact and the absence of air resistance in the near-vacuum tube, Hyperloop can achieve high speeds at relatively low energy requirements. Indeed, its energy efficiency is one of its key benefits, according to preliminary studies. Our own research shows that emissions are five times lower than those of its closest land-based counterpart, high-speed rail (HSR), and almost 25 times lower than commercial aircraft.

At the same time, there can be no doubt that building the infrastructure needed for Hyperloop will have a significant environmental impact. Land will be required, along with sizeable investments in steel and concrete. However, at a time when we see countries investing heavily in electrifying their vehicle fleets, and in some cases seeking to enlarge their rail and airport infrastructure, Hyperloop systems are certainly worth considering as a possible answer to a cleaner future for transportation.

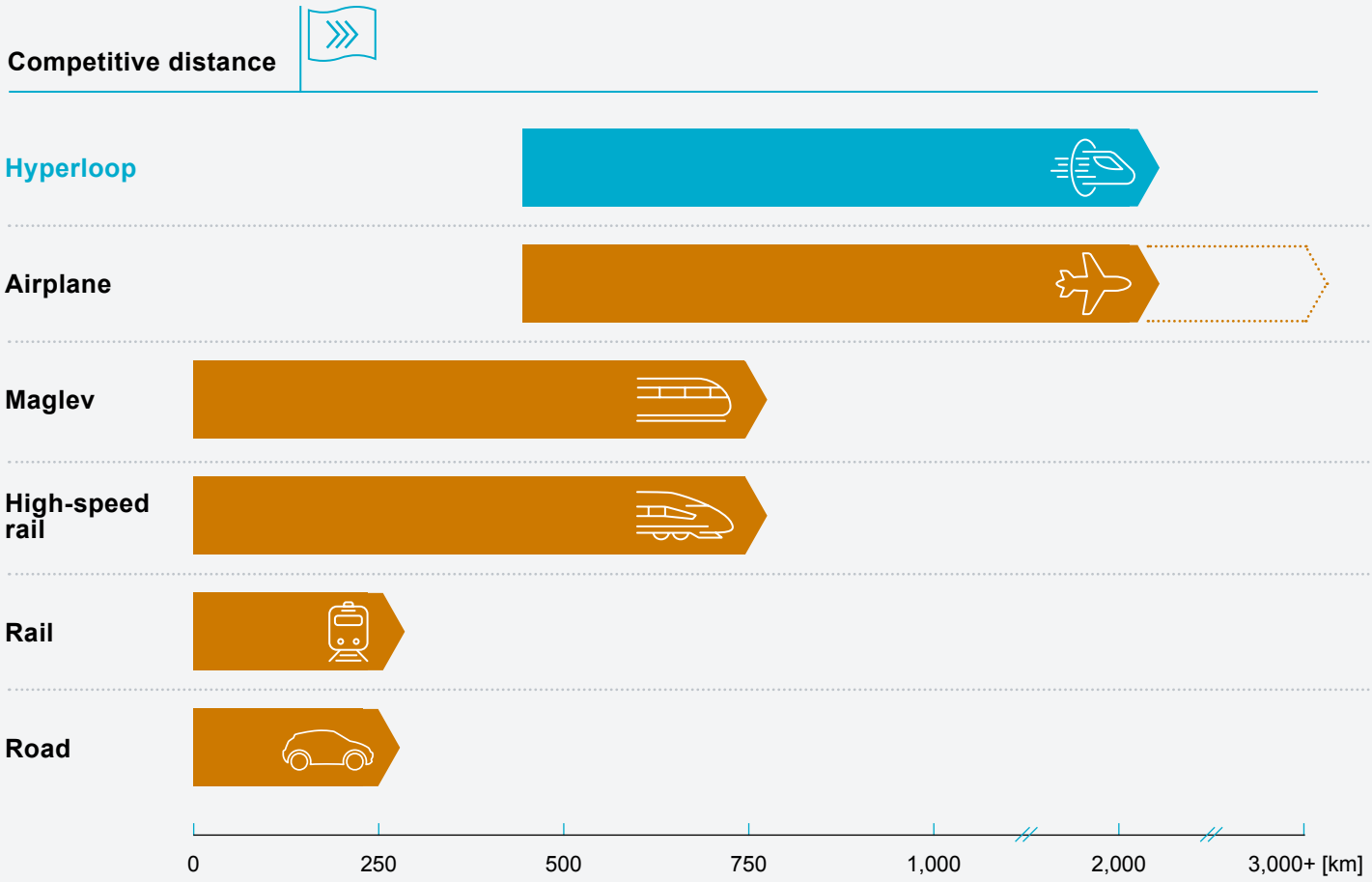
THE NEED FOR SPEED

Much of the attraction when it comes to Hyperloop is its promise of speed – especially when the talk is of speeds of up to 1,200 km/h, not far from the speed of sound.

Are such speeds realistic? Operating speeds, which aim to optimize energy efficiency, are in fact more likely to be around 800 km/h. This would still be an impressive feat, given that it entails a land-based mode of transportation traveling at the speed of commercial planes. Such speeds could revolutionize travel

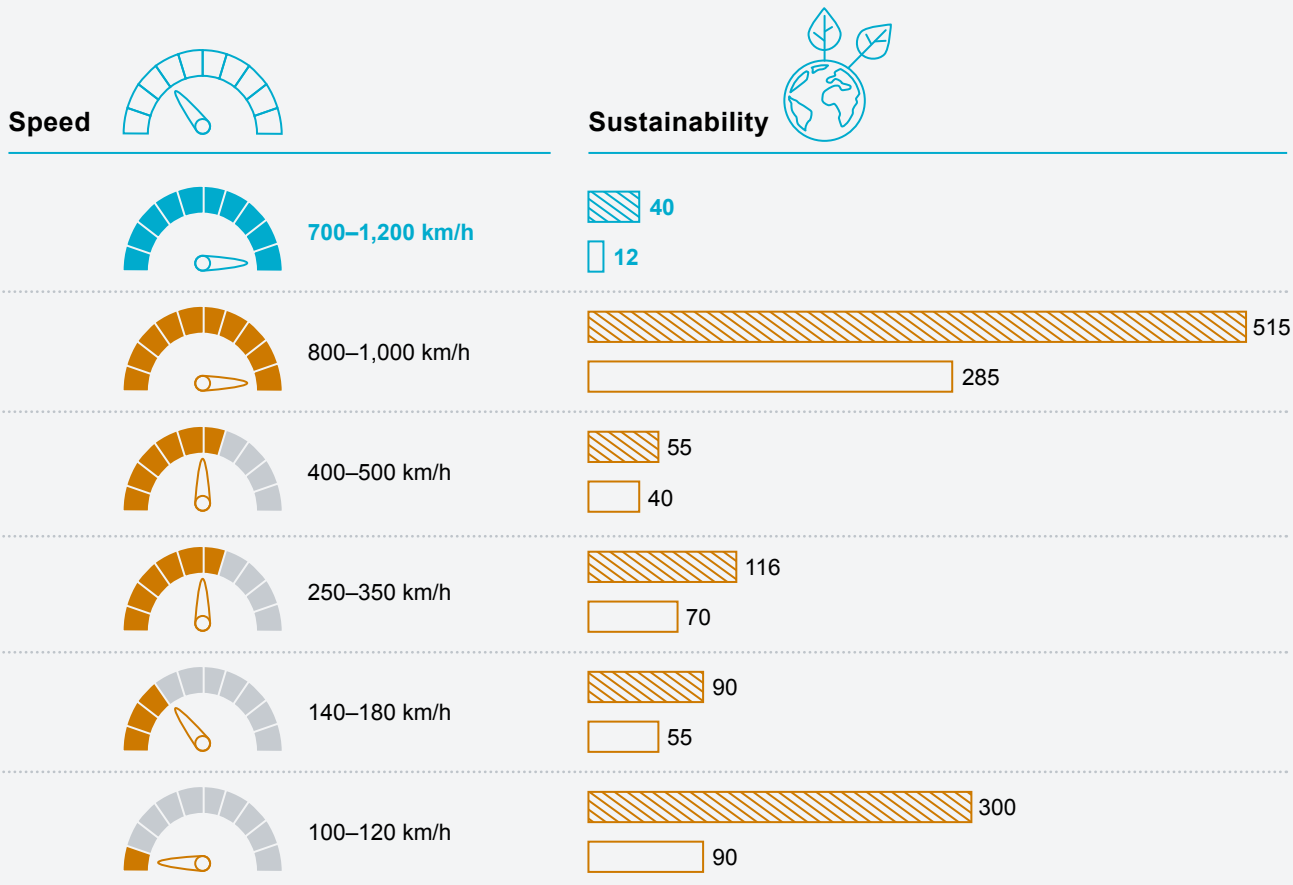
D / A winning combination

Comparison of Hyperloop with other modes of transportation



between major business centers such as Dubai and Riyadh – today, one of the most profitable airline routes globally and among Emirates airline's busiest routes, serving the needs of business travelers on their weekly work commute. The distance between the two cities is more than 800 km, and flying involves airport commutes on either side of the journey, airport wait times and an actual flight time of 90 minutes. This means passengers need to set aside around four hours for a trip by airplane between the two cities. With Hyperloop? The journey time could be cut by at least half.

Naturally, Hyperloop would heavily impact the use of existing modes of transportation. A recent Roland Berger study highlights the expected modal shift following the introduction of Hyperloop technology. On selected long-distance corridors, we foresee a 40% decline in domestic air travel as a result of passenger willingness to shift to Hyperloop. A comparison of Hyperloop technology with existing modes of transportation indicates that Hyperloop offers a winning combination of speed and a relatively clean environmental profile. → D



Source: European Environment Agency, expert interviews, secondary research, Roland Berger consortium analysis

3/ So, why the delay?

Has Hyperloop run out of steam?

Given the evident advantages of Hyperloop systems, as outlined in the previous chapter, the obvious question is: why is there no Hyperloop up and running? What is stopping the technology from being implemented in practice?

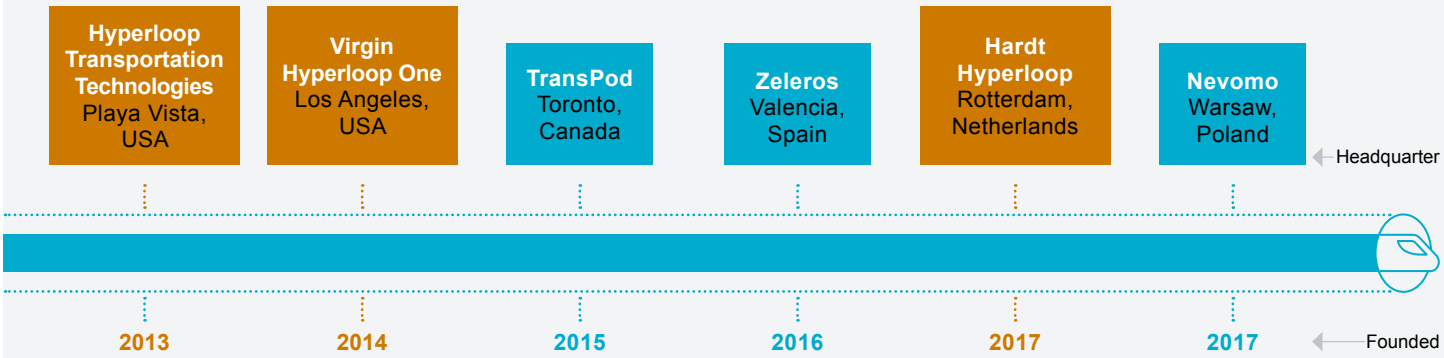
A decade on from the Hyperloop Alpha document, a number of players are trying to turn the dream into a reality. Virgin Hyperloop One, Hyperloop Transportation Technologies (HTT) and Hardt currently lead the field, and test sites have been built in various locations across the United States and Europe. So far, only Virgin Hyperloop One has actually tested the technology with passengers. Their trials, conducted in November 2020, were a landmark achievement for the industry, although the speeds of 170 km/h reached were still a long way off from the ambitions for the technology.

Since its human trials, Virgin Hyperloop One has made the strategic decision to concentrate on freight, and the industry generally appears to have settled on the idea of achieving interim success with freight before moving on to passenger travel. Hardt is taking a similar approach at its European Hyperloop Center in the Netherlands. Proving that the technology works, regardless of what is inside, would appear to be a sensible way forward for an industry looking to show investors that it has a promising future. → E

The public sector can play a key role in the future of Hyperloop. Around the globe, governments have been involved in Hyperloop projects, primarily feasibility studies. → F

E / Of the six leading Hyperloop players, Virgin Hyperloop One, Hardt and HTT are deemed to be leading the way

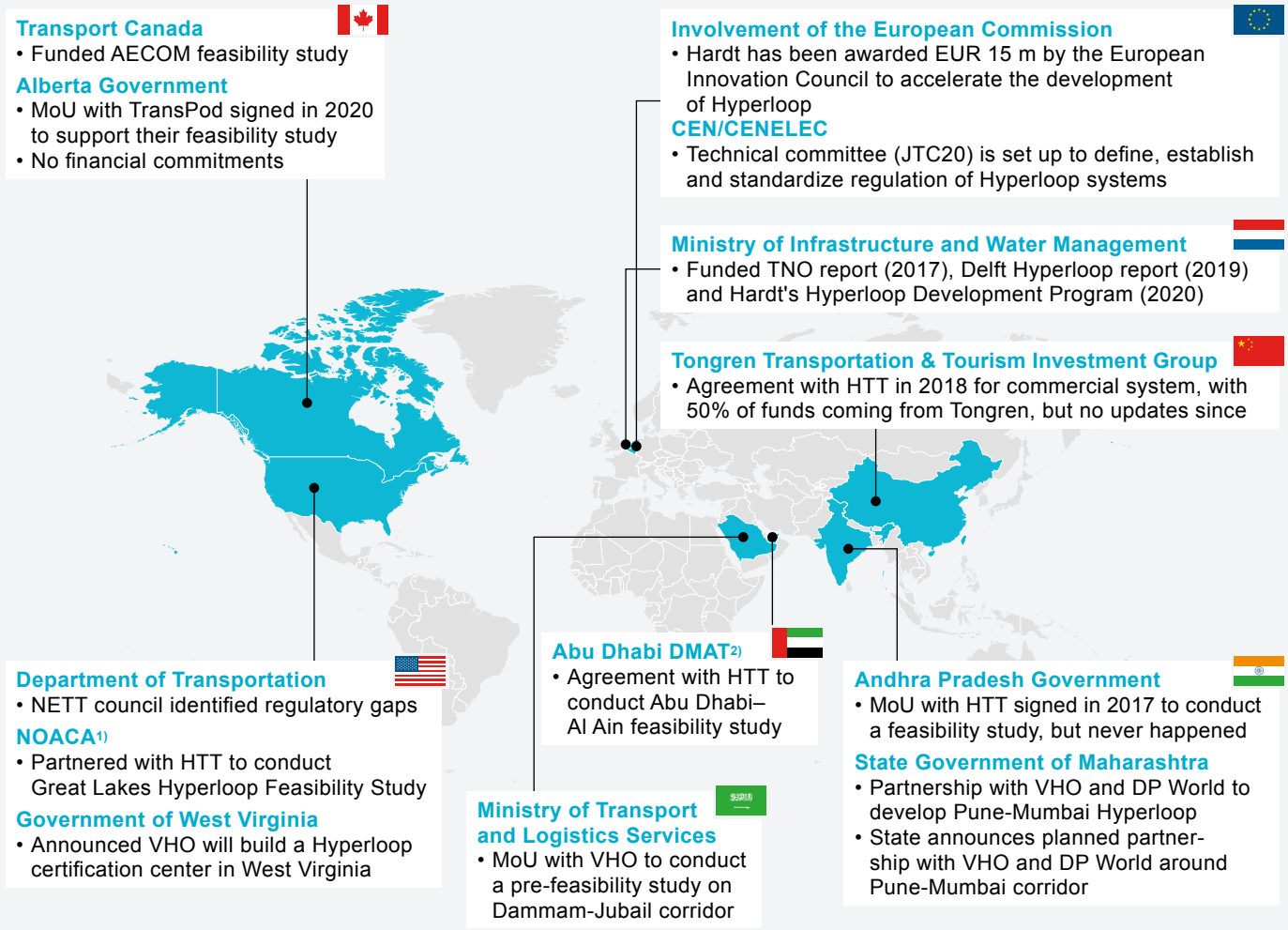
Hyperloop companies – Overview



Source: Hyperloop Transportation Technologies, Virgin Hyperloop One, TransPod, Zeleros, Hardt, Nevomo

F / Governments are interested

Sample government involvement in Hyperloop projects



1) Northeast Ohio Areawide Coordinating Agency 2) Department of Municipal Affairs and Transport

Source: Desk research, Roland Berger consortium analysis

Of course, when developing a completely new form of transportation, technology readiness is just one factor among many. The innovation also needs to offer social and commercial benefits. In the case of Hyperloop, public stakeholders need to understand that the new mode of transportation could revolutionize how people live, work and move, much in the way the railroads did in the 19th century. It will become possible to commute over longer distances in significantly shorter times, enabling the development of new urban centers and hubs across countries and regions. At the same time, it would be a mistake for large-scale infrastructure investments to be limited to the public sector. Although governments will of course be closely involved in planning, investment by private players – and competition among those players – should be encouraged, as was the case historically with railroads.

4/ Outlook

How to gain new momentum

Where is Hyperloop headed? Our research indicates that a strong case exists for the new technology compared with existing modes of transportation. Although the system's technical features have yet to be proven on an operational basis, no major concerns about its feasibility appear to exist.

As of today, the technology has failed to advance in the mainstream primarily due to the lack of public-sector backing. This has led to a lack of momentum in the industry in recent years. For Hyperloop to take off, we believe that governments and other stakeholders must collaborate more effectively, mitigating the risks on both sides. Without such collaboration, the future of Hyperloop is uncertain.

A number of steps can be taken to bolster such collaboration, further engage the public sector and create new momentum in the industry. We recommend the following:

- **Establish a clear regulatory framework:** a clear regulatory framework is key to Hyperloop's success. For example, the European Commission recently announced that it will propose an EU regulatory framework for Hyperloop, to ensure readiness to accommodate the high-speed, low-carbon transportation solution. Similar frameworks should be established in other regions.
- **Use public money to stimulate the private sector:** public funds can cover part of the investment costs for Hyperloop, thereby bearing some of the risks involved in the early stages of technology development. Many private players are currently taking a wait-and-see attitude, reluctant to make the major investments required or bear the full risk of projects – after all, the first transportation corridor built is likely to represent an unattractive business case. Public money to stimulate development could be made available on a local or national level, or even come from major international institutions, similar to the investment of the European Commission into Hardt.
- **Secure public land for testing facilities:** longer test tracks are required in order for Hyperloop to achieve technology readiness and prove its safety at operating speeds. Governments should be encouraged to provide the large areas of land needed for such test facilities. Ideally, these test tracks would lie along the route of potential Hyperloop corridors, so as to save on future investments.

YOUR CONTACTS

Looking for more information about the potential of Hyperloop?

Schedule a meeting or video call with one of our experts

AUTHORS

MIDDLE EAST
René Seijger
Senior Partner
rene.seijger@rolandberger.com

Tobias Schönberg
Senior Partner
tobias.schoenberg@rolandberger.com

Santiago Castillo
Senior Partner
santiago.castillo@rolandberger.com

Farhan Chhabu
Project Manager
farhan.chhabu@rolandberger.com

EUROPE
Tim Vleeshouwer
Consultant
tim.vleeshouwer@rolandberger.com

CONTACTS

AMERICAS
Marc Winterhoff
Senior Partner
marc.winterhoff@rolandberger.com

ASIA
Lei Li
Partner
lei.li@rolandberger.com

Manas Trivedi
Project Manager
manas.trivedi@rolandberger.com

EUROPE
Didier Bréchemier
Senior Partner
didier.brechemier@rolandberger.com

Casper Veenman
Partner
casper.veenman@rolandberger.com

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ROLAND BERGER GmbH
Sederanger 1
80538 Munich
Germany
+49 89 9230-0

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