Hyperconnected Europe

A vision for the European hyperloop network

July 11, 2022 / Version 1.5

hyperloop development program

Table of contents

What is 'Hyperconnected Europe'?

Hyperconnected Europe is an ongoing initiative involving a community of cities and regions that have come together to create a shared vision for a European hyperloop network.

Together, they are shaping a system that can radically improve connectivity and contribute to net zero by 2050. The initiative is a part of the Hyperloop Development Program (HDP), a public-private collaboration dedicated to bringing hyperloop to reality.

This vision paper outlines the European hyperloop network and is the result of research and contributions by HDP partners, Hardt Hyperloop and the Hyperconnected Europe community.

From February to June 2022, various webinars and workshops have taken place around topics such as passenger and freight services, hubs (stations), infrastructure integration, and network design. The inputs and feedback gathered from participating cities and regions have been incorporated into this paper, setting a baseline for further refining the European hyperloop system and bringing it closer towards realization.

Hyperconnected Europe invites readers to explore a zero-emissions future, where hyperloop can foster a more competitive economy and inclusive European society. One that is more integrated and resilient, while facilitating energy efficient long-distance transport.

Let's work together to create a Hyperconnected Europe.

Cover: Hardt Hyperloop station platform. Design by UNStudio. Render by Plomp

Executive summary

In Europe, transport demand is projected to grow by up to 28 percent for non-urban passengers, and up to 92 percent for freight by 2050. This puts strain on existing infrastructure and the European Green Deal goal of climate neutrality by 2050.

Hyperloop, an energy efficient, fast, and flexible mode of transport for passengers and goods, is a necessary piece of the puzzle for achieving net zero mobility. It offers travelers a sustainable alternative for continental flights, combining the speed of an aircraft with the convenience of a train. Hyperloop can also carry time-sensitive goods, providing an alternative to continental air freight and long-haul trucks. By bringing cities, citizens, and business closer together, hyperloop can play a pivotal role in shaping European and global integration.

Figure 1. The hyperloop passenger experience.

A hyperloop network covering close to 25,000 kilometers would connect all European Union member states (except for islands), member candidates, and adjacent economies. Building this network would require an estimated investment of €981 billion, or about 10 percent of the total transport infrastructure investment required for Europe up to the year 2050. By this year, an estimated 1.3 billion passengers (1.3 trillion passenger-kilometers) and 625 million tonnes of freight (389 billion tonne-kilometers) could be transported by hyperloop, thereby reducing flight kilometers travelled by 66 percent and long-haul truck movements by 18 percent. This could result in a reduction of between 113 and 242 million tonnes of CO_2 per annum by 2050. The costs of hyperloop investment could be recovered through passenger fares and transport rates similar to aviation and trucking, reducing the total cost impost.

Table 1. Estimated costs, revenue, and benefits of a full European hyperloop network in 2050

Item (in 2050)	Value (in billion €)
Total network CAPEX	981
Annual network OPEX	48
Annual revenue	248
Annual Wider Economic Benefits	192-294

Hyperloop can be integrated by respecting the existing structure of European cities. It features lower space requirements than other transport corridors, and does not contribute to vibration, noise, and fine-particulate matter emissions.

The Hyperconnected Europe initiative will continue to work with cities and regions across Europe to build on the shared hyperloop vision, and to accelerate its introduction into the multimodal transport ecosystem.

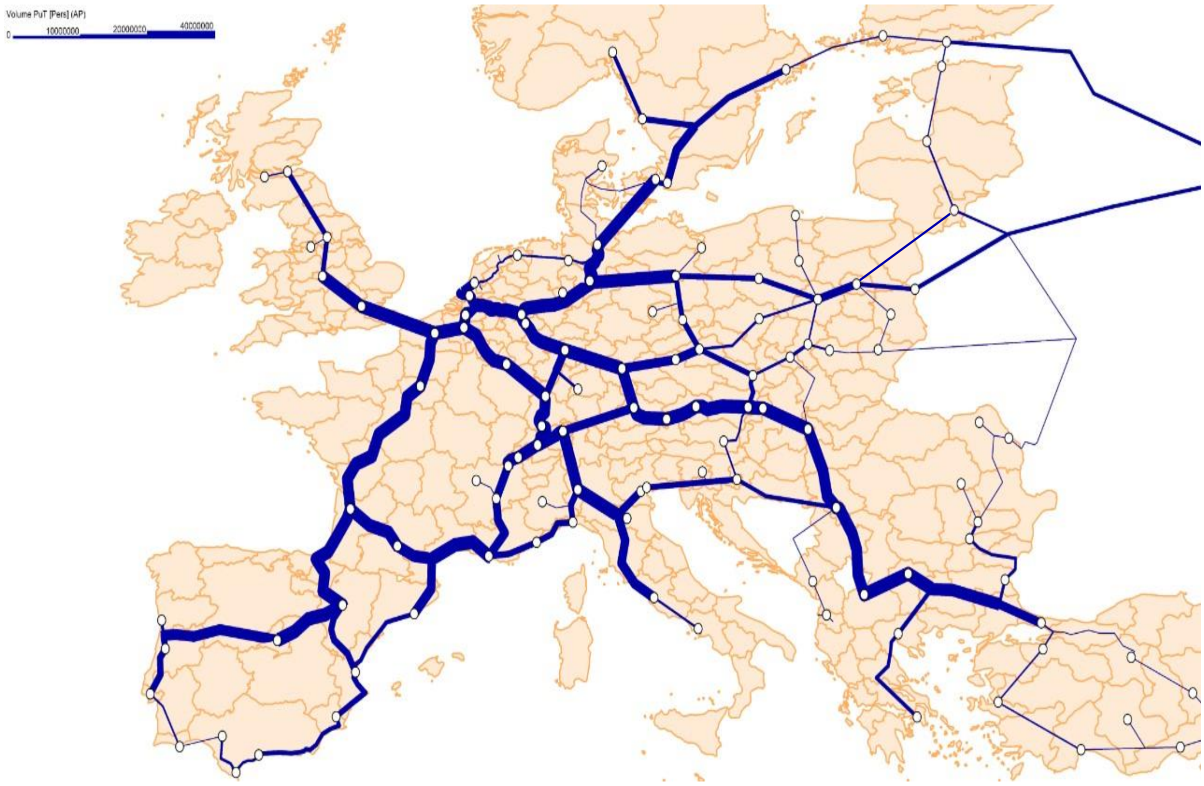


Figure 2. Preliminary traffic volumes of a hyperloop network generated by Hardt Hyperloop's "VESSEL".

About the Hyperloop Development Program

The Hyperloop Development Program (HDP) is a public-private partnership initiated by the Dutch Ministries of Economic Affairs and Climate Policy, Infrastructure and Water Management, the Dutch Province of Groningen, and a group of industry parties and knowledge and research institutions. They are dedicated to developing hyperloop as a safe, sustainable, and viable mode of high-speed mobility, and to bring the hyperloop to realization.

The program aims to achieve the following goals:

1. To prove hyperloop as a safe, sustainable method of moving people and goods.
2. To test and demonstrate through the European Hyperloop Center that the technology works as designed and can be operated safely.
3. To identify prospects and opportunities for industries and stakeholders to cluster around the hyperloop ecosystem.

The goals of the program are comprehensively addressed by focusing on several activities such as research and development projects, feasibility studies, and the realization of the European Hyperloop Center.

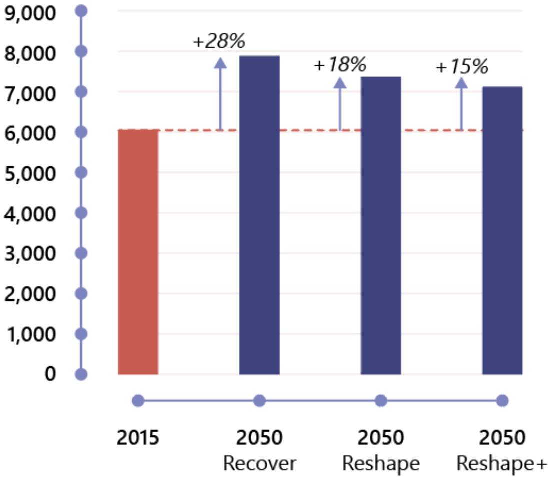
Figure 3. Hyperloop Development Program partners, as of June 2022.

The European transport challenge

Private vehicles, rail, and aviation have transformed cities and lifestyles around the world since the 19th century. These modes were considered technological breakthroughs for their time and have shaped how people live today. However, governments must now contend with negative aspects of their use, particularly in relation to private vehicles and aviation.

Continuing urbanization, environmental degradation, resource scarcity, growing consumerism, and rising inequality represent just some of these challenges.

In Europe, transport demand is projected to grow by up to 28 percent for non-urban passengers, and up to 92 percent for freight by 2050 (over 2015 levels), despite the changes to travel behavior resulting from COVID-19[1]. This growth will test the limits of existing approaches to meet future demand and tackle global megatrends such as climate change.



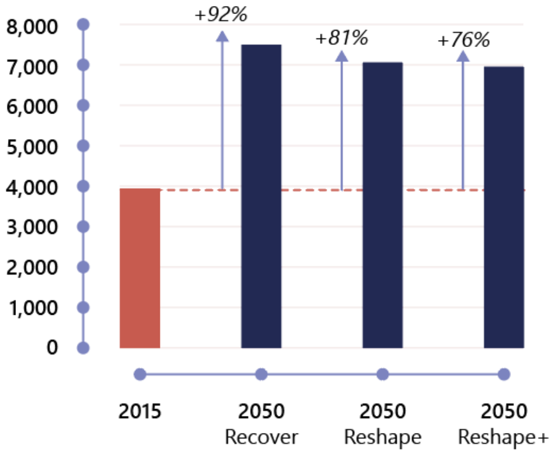


Figure 4. Predicted growth of non-urban passenger transport and freight transport in Europe.

Passenger needs

While governments have sought to increase sustainable transport and offer people more travel choices through walking, cycling and public transport, the transportation industry is reaching a critical point, as the existing ways to move people and freight are reaching capacity. For every kilometer traveled in Europe, 71 percent of them was done through a private vehicle in 2019[2]. These trips take place in traffic, with the average motorist in Berlin losing 2.9 days per year due to road congestion[3]. Major airports across Europe are also returning to their pre-pandemic levels of congestion, adding to the climate cost.

[1] OECD – International Transport Forum, Transport Outlook 2021: https://www.oecd-ilibrary.org/transport/itf-transport-outlook_25202367

[2] Statista – Share of passenger mileage in EU-27 in 2019, by mode: https://www.statista.com/statistics/280520/share-of-passenger-mileage-in-eu-27-by-mode/

[3] TomTom – Traffic Index Ranking 2021: https://www.tomtom.com/en_gb/traffic-index/ranking/

The consideration of new ways to deliver large-scale transport infrastructure is vital for planners, given the costs, complexities and policy objectives associated with Europe's legacy transport systems. For example, barriers to high-speed rail delivery include cross-border regulations, complex operating models, and the slow digitization of rail systems. On the policy front, governments are progressively banning short-haul flights. Some have placed a moratorium on road building.

Freight requirements

The growth in consumption has accelerated e-commerce trends and time-sensitive freight movements, creating supply chain issues for producers, manufacturers, wholesalers, and importers worldwide. People expect supermarkets to be fully stocked, their online purchases to be delivered quickly to their door, and the cost of goods be affordable. The difficulties in meeting these requirements are compounded by COVID-19 disrupting trade flows from Asia to Europe, and the conflict in Ukraine adding additional air kilometers and fuel expenses to airfreight operations.

How to solve future transport challenges

Amid these global challenges and the climate crisis, more needs to be done. Transport and mobility solutions are key to unlocking global environmental, social, and economic change. In many ways, the future of the world depends on whether passengers and freight can be moved more efficiently and sustainably over long distances. In this regard, hyperloop represents the next generation in transport and mobility – a mode built to address future challenges.

Global forecasts indicate that over €50 trillion in passenger and freight investments into existing modes of transport are required to keep pace with the projected growth to 2050. For Europe, this amounts to around €10 trillion, of which around 90 percent are allocated to road and rail projects. [4]

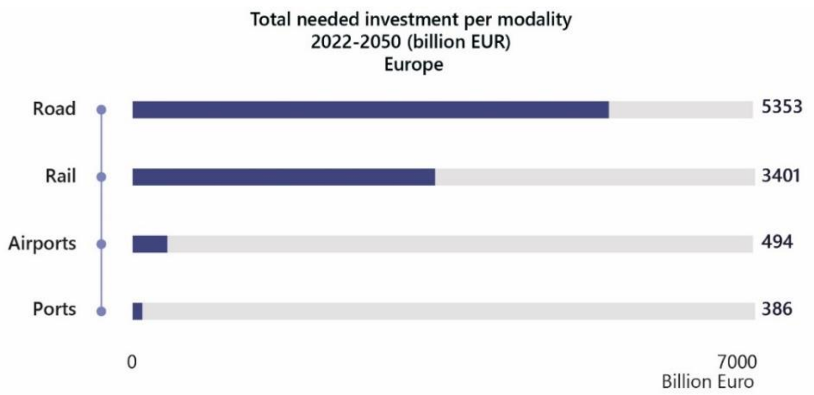


Figure 5. Total needed investment by mode, from 2022 to 2050. Note: Estimates are based on a linear extrapolation of G20 investment requirement projections from 2017 to 2040. Source: https://outlook.gihub.org/

Under the right policy and regulatory settings, hyperloop can reduce car and truck use, substitute short-haul flights, and complement high speed rail, in support of overarching policy objectives, such as the UN Sustainable Development Goals and the European Green Deal.

[4] Global Infrastructure Outlook: https://outlook.gihub.org/

What is hyperloop?

Hyperloop is a fully digital mode of transport with vehicles travelling through a network of low-pressure tubes, using less energy than aviation, road, or rail-based transport. Capable of high-speeds and driverless operations, it offers continuous capacity for moving passengers and freight without intermediate stops, in a predictable manner. The hyperloop infrastructure can be elevated, at-grade, or underground. Vehicles resembling small aircraft travel inside the tube, either separately, or in short trains of virtually coupled vehicles.

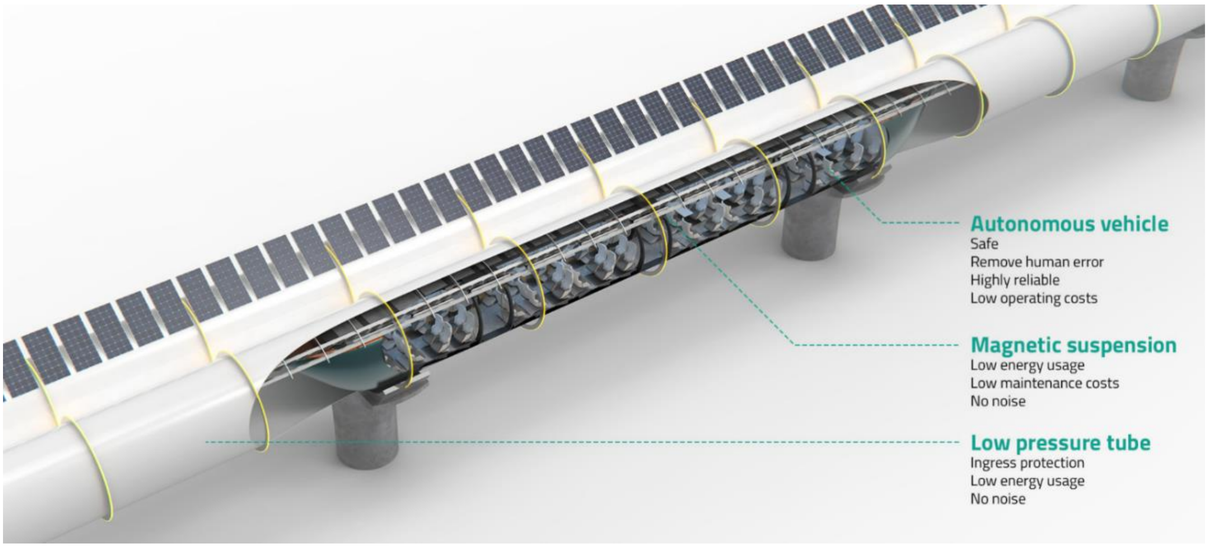


Figure 6. The hyperloop system.

Sustainable high-speed transport Hyperloop combines current technologies from different industries into a new mobility concept – digital from day one. Instead of trains using wheels on rail, the system uses magnetic forces and vacuum pumps for levitation, guidance, and propulsion. Air resistance and noise becomes a major factor for existing high-speed modes. Hyperloop solves this by operating pressurized vehicles inside a low-pressure tube. The low-pressure environment reduces air resistance and energy consumption, allowing propelling vehicles to reach speeds of over 700 kilometers per hour.

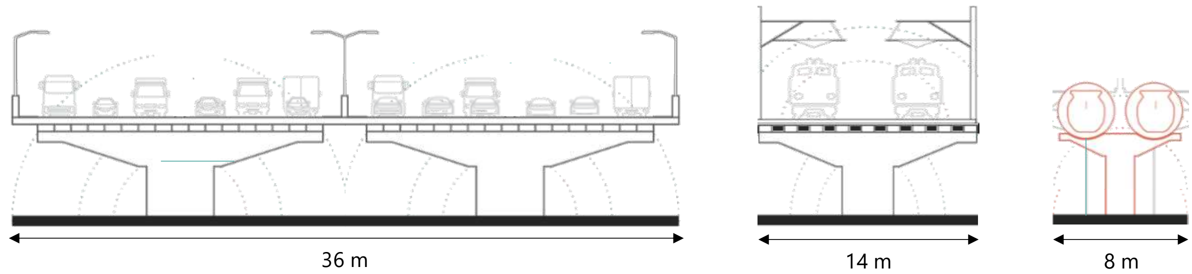


Figure 7. The footprint of a road, rail, and hyperloop corridor for moving at least 16,000 passengers per hour, per direction.

Autonomous, high-capacity switching

Hyperloop is designed to operate like an autonomous highway network. As hyperloop expands from a single corridor to an interconnected network that serves many destinations, switches will be needed for vehicles to seamlessly shift from one tube to another. Conventionally, manual switches in a guided network (such as rail), represent a source of traffic bottlenecks and unplanned service disruptions. Hyperloop's magnetic switch features no moving parts, allowing vehicles to change direction from one tube to another at high speeds. This is a key feature of the hyperloop system, as it allows vehicles in the core corridor tube to maintain cruising speed, without having to slow down for vehicles entering or exiting (see figures below).

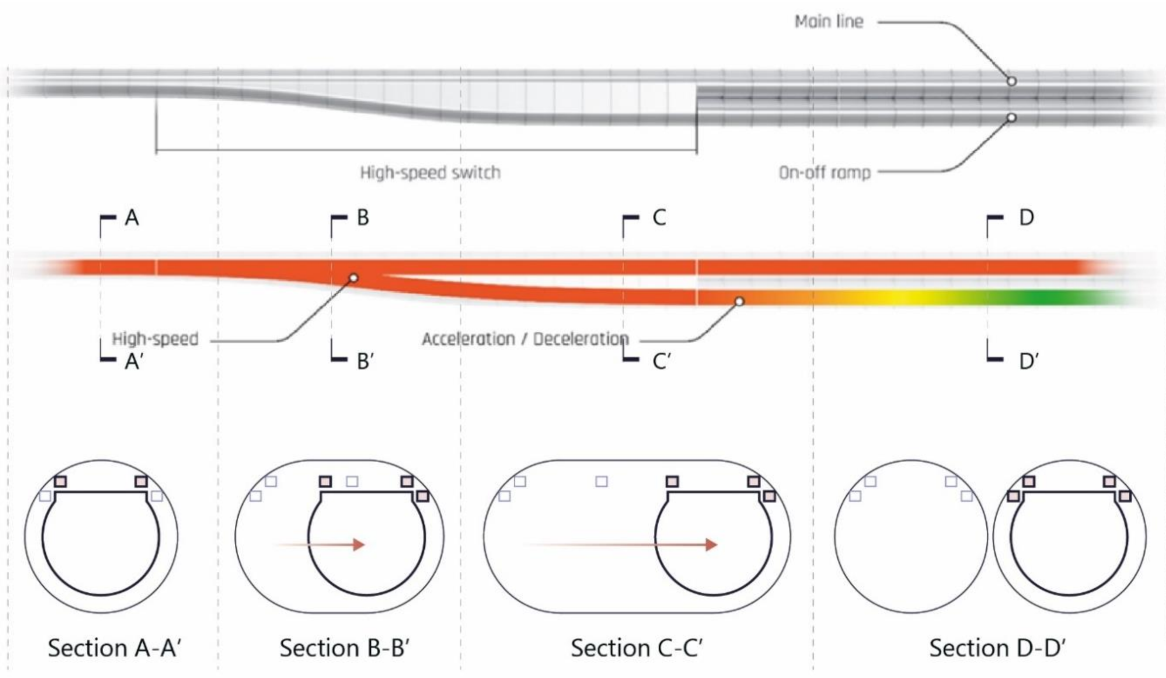


Figure 8. Hyperloop's high-speed switch and turnout.

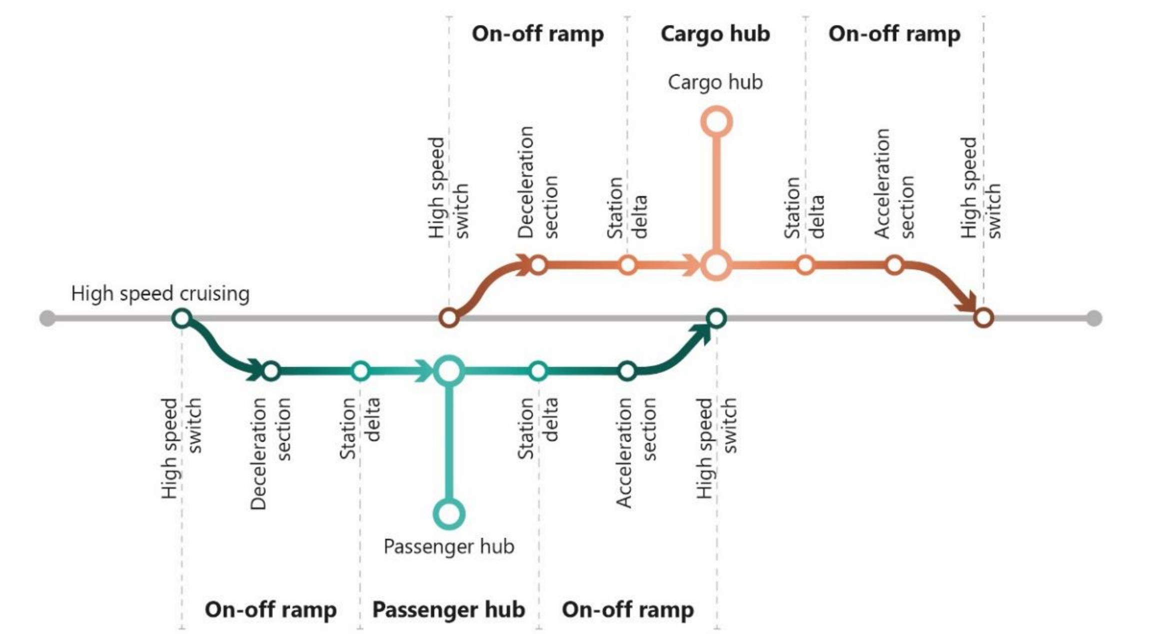


Figure 9. Hyperloop's high-speed cruising corridor, and on-off ramps.

Hyperloop's network components

The hyperloop network (covering its infrastructure and services) consists of:

Component	Description
Core or local corridors	The linear infrastructure (tubes) that connects hyperloop hubs with each other. It allows vehicles to traverse through it at high speeds.
The switches or turnouts	Components of the corridor that create a bifurcation (or branch), allowing some vehicles to continue on a core corridor, and others to enter or exit.
On-off ramps, entrances and exits	Components of the corridor that are connected to the turnouts, allowing vehicles to decelerate when exiting a core corridor, and to accelerate when entering a core corridor.
Passenger or freight hubs	Hyperloop uses the same linear infrastructure for passengers and freight. However, its hubs can be dedicated towards passenger or freight-based operations.
Autonomous vehicles	Vehicles can be configured to seat all passengers or accommodate palletized goods.
Additional components	Vacuum pumps, stabling and maintenance facilities, and emergency (fire and life safety) exits.

Setting the industry standards

Global players in the hyperloop industry are partnering to standardize hyperloop technologies through the *European Committee for Standardization* (CEN) and the *European Committee for Electrotechnical Standardization* (CENELEC).

Standardization will enable seamless hyperloop travel in a fully interoperable network. Standardized systems and interfaces between systems, subsystems, as well as a common language for testing and manufacturing will enable "safe-by-design" and seamless hyperloop operations, while at the same time minimizing development risks.

Setting a single interoperable standard extends to a broad collaboration, with experts from academia, operators and industries jointly contributing to technical discussions at the European Joint Technical Committee 20 (or JTC20: Hyperloop Systems). These standards will set the foundation for building a hyperloop technology that will truly empower people and meet the needs for sustainable mobility.

Following the systems engineering approach to standardization, JTC20 members have agreed to work on a series of standards. The standardization of the hyperloop system as a new transport mode calls for a reference architecture to first be developed, by defining all the systems and subsystems of hyperloop, as well as defining the requirements and services for the movement of passengers and freight.

Why hyperloop for passengers?

Figure 10. Hardt Hyperloop station platform. Design by UNStudio. Render by Plomp.

Hyperloop's role in the future transport network can be determined by how it can best support the policy agenda that drives multimodal decision-making across Europe. In the context of the climate crisis and the European Green Deal, hyperloop can promote specific policy objectives, such as reducing long-distance truck movements, and replacing or substituting short-haul flights. It can also be introduced to enhance the attractiveness of existing sustainable travel choices, by integrating effectively with walking, cycling, and public transport.

A sustainable replacement for short-haul flights?

The emerging policy initiatives to ban or disincentivize short-haul flights in favor of more environmentally friendly options provide hyperloop with the opportunity to deliver a zero-emissions alternative. The movement to reduce short-haul flights started in 2006, when the Government of Wallonia banned flights between Charleroi and Liège (100 kilometers). In 2020, France and Austria imposed bans for flights equivalent to 2.5 and 3 hours of train travel respectively. Austria provided a further disincentive, introducing a surcharge of €30 for all flights less than 350 kilometers.

Passenger service characteristics

As part of the work carried out by the Passenger Working Group of the Hyperloop Development Program, an initial set of passenger services have been defined. These describe the service characteristics that hyperloop aims to offer, to play a complimentary role in the future mobility mix. The service characteristics (capacity, convenience, reliability, punctuality, low journey time, and vehicle facilities), are shown in the following table.

Table 2. Passenger service characteristics.

Service characteristic	Service requirement	Operational parameter
Capacity	High-capacity tubes, with a throughput that is comparable to mass transit on core corridors.	A core corridor capacity greater than 20,000 passengers per hour, per direction, including passengers with restricted mobility (PRMs), and the possibility for platooning.
Convenience	Frequent departure and arrivals, with easy or few transfers, and a short access and egress time.	Vehicles feature multiple large doors at both sides for quick embarking and disembarking.
Reliability and punctuality	On-time-running to be higher than current rail and aviation services.	A fully enclosed operating system immune to weather and level crossings. A fully automated system reduces human error.
Low journey time	Low access, in-vehicle, transfer and egress travel times, egress times, as well as low last-mile travel times.	The combination of fast and seamless travel components makes hyperloop suited to trips of up to 2,500 kilometers in length.
Vehicle facilities	Features include PRM facilities, passenger seatbelts, and lavatory access.	PRMs can embark and disembark on their own during normal and emergency operations. Seatbelts and lavatories are present in every vehicle.

Note: A characteristic covered separately to the Hyperloop Development Program's Working Groups is the cost of the using hyperloop services for the paying passenger. It is envisaged that hyperloop's fares will be comparable to high-speed rail journeys for passengers. The table below illustrates how the above characteristics come together to create a seamless experience through several passenger "touchpoints."

Table 3. Touchpoints related to the passenger journey.

Touchpoint	Description
Flexible ticketing	**Improves convenience.** Hyperloop tickets can be reserved to ensure a booked seat (like commercial flights). However, they can also be sold as a subscription that allows for "on-the-fly" boarding, subject to availability (such as public transport).
Easy access to hub	**Improves convenience and journey time.** Hyperloop hubs are intended to be multimodal and integrated as close as possible to city centers, where major interchanges occur. It is anticipated that some hubs will be located outside the city centers, but not as far as airports.
Right of travel at walking pace	**Improves convenience and journey time.** Passenger identification, ticket, and security checks should be as seamless as possible. The goal is to have these processes occur concurrently at a walking pace, without having to stop.
Short embarking time	**Improves reliability, punctuality, and journey time.** Passenger boardings should be quick and efficient, similar to rail services. Small vehicles and large openings will facilitate this. This reduces total journey time and improves service frequencies.
Short trip	**Improves journey time.** In-vehicle travel times between origin and destination hubs (including acceleration, cruising speed, and deceleration), should be as fast as possible, to unlock the benefits associated with major travel time savings.
Short disembarking time	**Improves reliability, punctuality, and journey time.** Passenger disembarking should be quick and efficient, like rail services. Small vehicles and large openings will facilitate this. This reduces total journey time and improves service frequencies.
Connected exit and short transfer	**Improves convenience.** Hyperloop hubs are intended to be multimodal and integrated as close as possible to city centers, where major interchanges occur. Transferring to other modes of transport for the continuation of the journey, or for the last mile, should be as seamless as possible.

Combining rail and aviation attributes

The goal of hyperloop's passenger services is to offer a similar experience to rail or metro in terms of convenience and operational efficiency, with the added benefits of a mode that can travel as fast as airplanes. The result is a new generation of transport that is convenient, seamless in experience, redresses the issues of long waiting or access times from existing modes, and allows passengers to travel further in less time. The image below shows the benefits of rail and aviation combined into what hyperloop can offer.

Figure 11. Hyperloop positioning as a modality. Graphic by Schweizer design.

A traveler's behavior is a complicated decision-making process. The factors influencing their mode choice revolve around the availability of services or infrastructure (for example, public transport availability, or car ownership), mode characteristics (for example, time, comfort, and cost), demographics, and customer attitudes and perceptions (for example, their values and habits).

Each mode in the mobility mix serves a range of different customer needs (or market segments). For some modes, this is the case, even if it is not the most suitable mode for all types of trips.

Comparing travel times

Modal selection relies on several key considerations, including cost, comfort, convenience, and most importantly, travel time. Hardt's transport simulation model 'VESSEL' compares travel times for all modes of transport – including hyperloop – by simulating their end-to-end journeys. The following examples illustrate VESSEL's travel time calculation between *Hyperconnected Europe's* supporting cities, showing improved end-to-end travel times for medium to long-distance journeys, making them compelling alternatives to driving and flying.

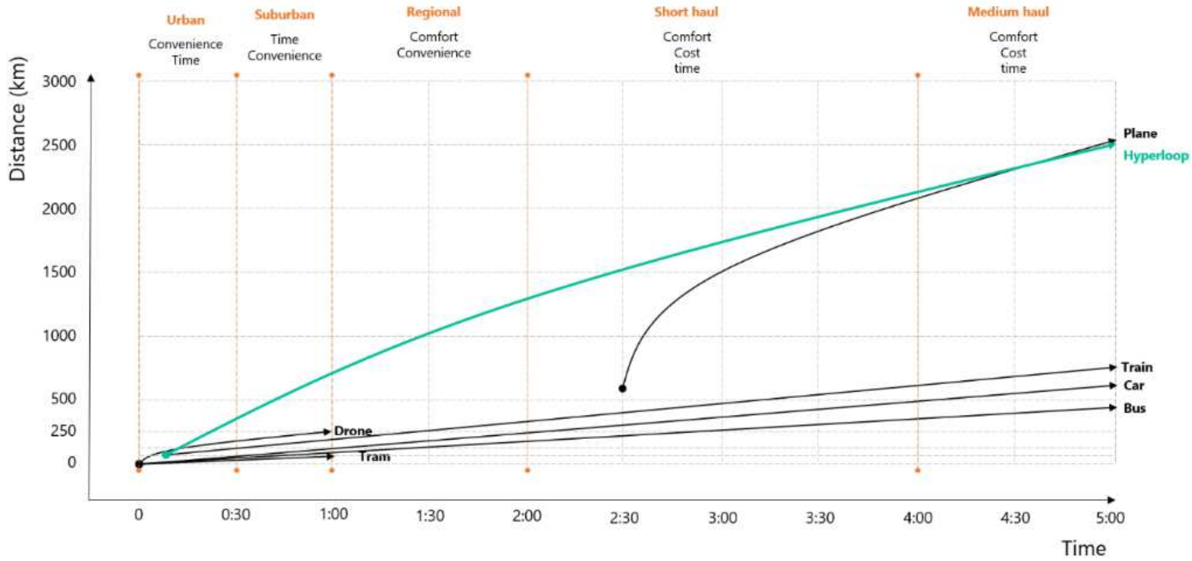


Figure 12. Time and distance comparison for various modes of transport.

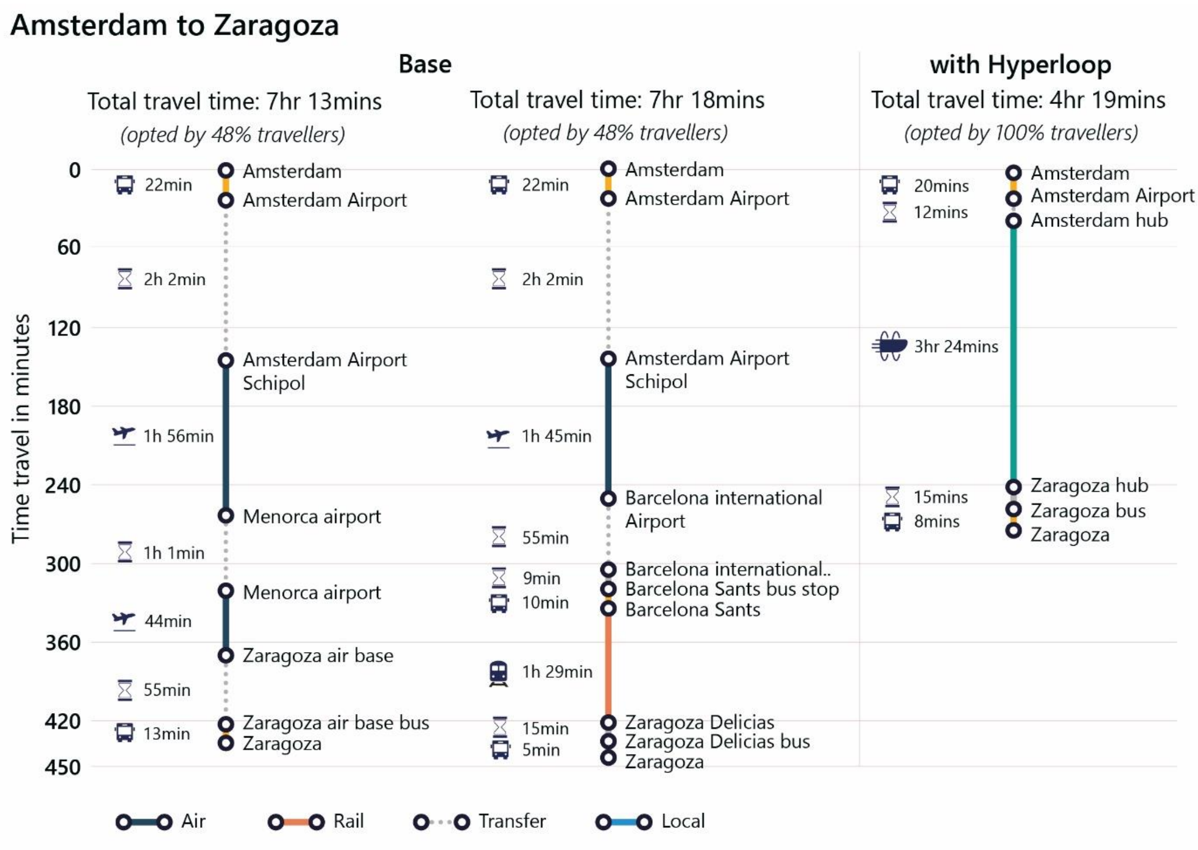


Figure 13. Travel time comparison by mode, from Amsterdam to Zaragoza.

Figure 14. Travel time comparison by mode, from Brussels to Munich.

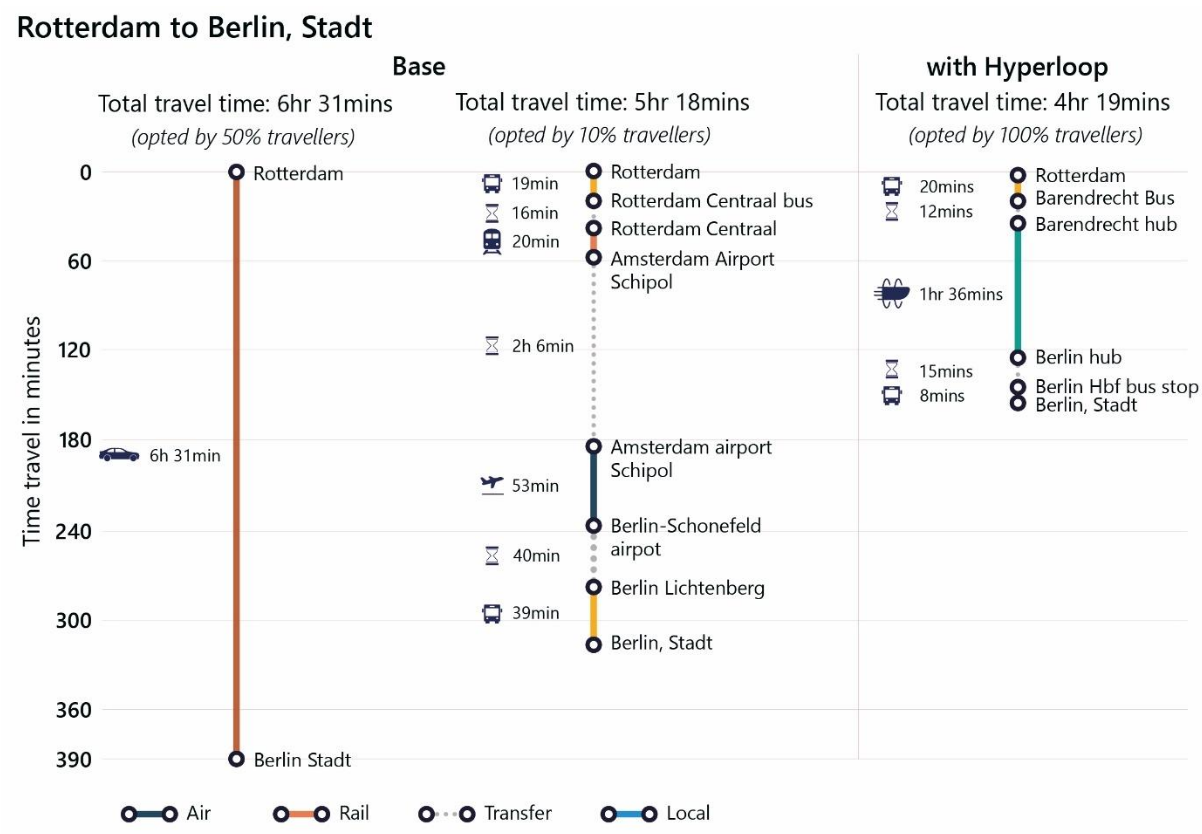


Figure 15. Travel time comparison by mode, from Rotterdam to Berlin.

How can hyperloop transform freight?

An integrated freight network is critical to the wellbeing of Europeans and the competitiveness of the European single market. However, in recent years, rising emissions, driver shortages, congestion bottlenecks, supply chain disruptions, and booming e-commerce sales have placed unrelenting pressure on the European logistics sector.

The demand for freight across Europe is expected to grow between 76 percent and 92 percent until 2050[5]. The European Union (EU) aims to address this future freight task through modes other than trucks to increase productivity gains, such as rail and inland shipping. It is therefore reviewing Trans-European Transport (TEN-T) policy. Through previous revisions, the policy has coped with growing transport needs, geo-political developments, and sustainability challenges. The European Commission realizes that the TEN-T policy must keep up with and pre-empt future scenarios to ensure a futureproofed and sustainable transport system[6].

Positioning hyperloop in freight's mobility mix

Given the rise of e-commerce and the pressures of the climate crisis, there is room for a new mode of transport that can profoundly change the way goods are moved. As a fast, flexible, and sustainable mode of transport, hyperloop can complement the existing mobility mix by offering a green logistics system for goods that require fast, frequent, and just-in-time distribution, with minimal energy consumption.

Five modes of transport	Road	Rail	Water	Air	Hyperloop
Transports individual pallets and parcels	✓	✗	✗	✓	✓
Delivers next day across EU	✗	✗	✗	✓	✓
High frequency	✓	✗	✗	✗	✓
Zero emission	✓/✗	✓	✓/✗	✗	✓
Local air/noise pollution	✗	✓	✗	✗	✓

Figure 16. Hyperloop as a new mode of transport for freight.

[5] International Transport Forum – Transport Outlook 2021: https://www.oecd-ilibrary.org/sites/16826a30-en/index.html?itemId=/content/publication/16826a30-en

[6] European Commission – TEN-T Review: https://transport.ec.europa.eu/transport-themes/infrastructure-and-investment/trans-european-transport-network-ten-t/ten-t-review_en

The ability to move goods across Europe and have it distributed on the same day would dramatically improve continental supply chains. Manufacturing clusters in the single market can be connected just-in-time, improving the efficiency and competitiveness of European businesses.

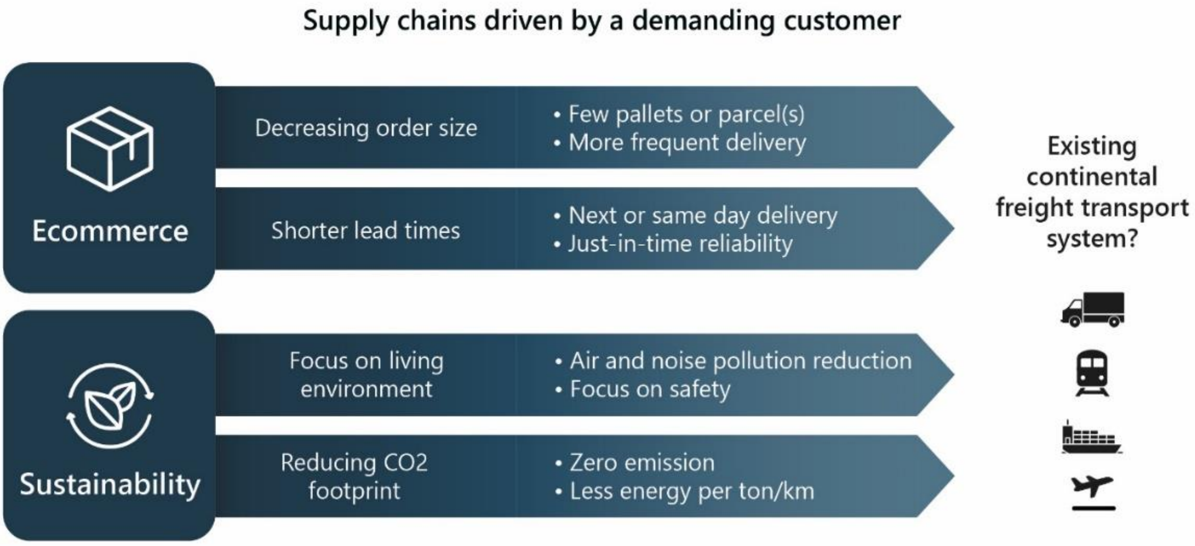


Figure 17. Supply chains driven by a demanding customer.

What types of goods is hyperloop suited to moving?

Hyperloop is suited to moving time-critical and high value goods, such as:

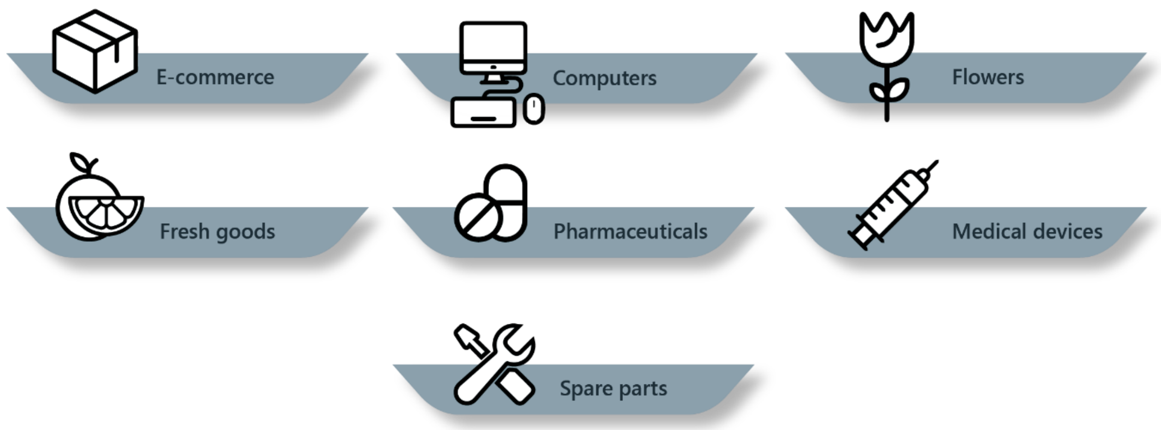


Figure 18. Types of goods suitable for hyperloop freight.

Door-to-door logistics

When goods travel across Europe, they often use a combination of modes to reach their destination. These involve intermodal terminals where they are transferred from one mode to the other. Hyperloop's freight hubs are designed to integrate seamlessly into existing logistics processes. All hubs provide a basic set of loading, unloading, and staging services. Larger hubs also provide value-added services such as container destuffing, palletizing, and sorting.

Figure 19. Example of freight hyperloop operations in a logistics facility.

To illustrate gains in the process an example is shown below for a Business-2-Consumer (B2C) order placed by a consumer in Northern Spain (Zaragoza), from a small-sized Dutch online business (Amsterdam). It greatly reduces truck movements, handling and lead time from 3-4 days to overnight.

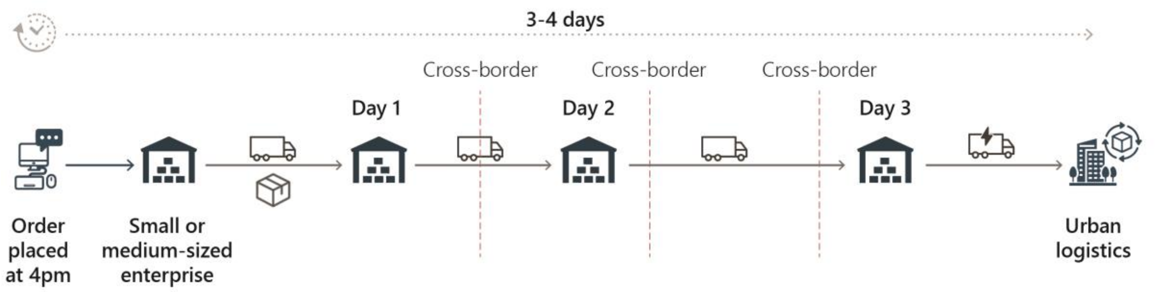


Figure 20. An example of parcels handled four or more times and transported by three or more heavy trucks from the Netherlands to Spain with a lead time of 3-4 days

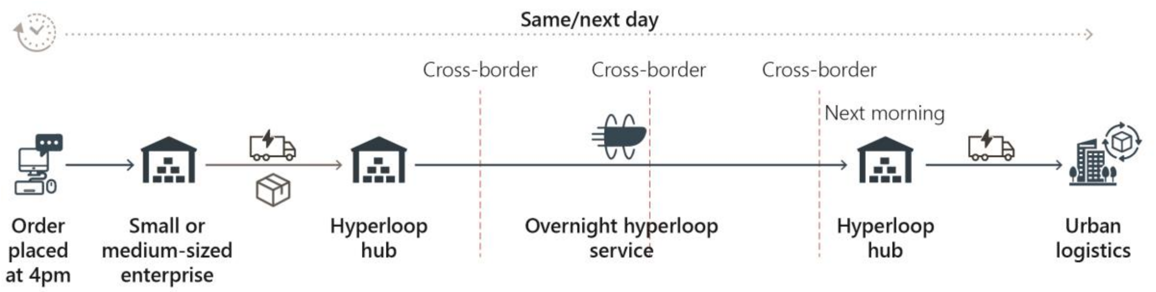


Figure 21. An example of parcels being delivered on the same/next day sustainably and cost-effectively from the Netherlands to Spain by hyperloop combined with zero emission first and last mile

Envisioning a future network

Great transportation systems start with a vision. This chapter looks at how the network was conceptualized, how its infrastructure could be integrated into urban settings, and what benefits future users can expect across the network. A hyperloop network has been developed for Europe, designed to facilitate the strategic objectives of the European Commission's TEN-T network.

Shaping the European hyperloop network

The Hyperconnected Europe network illustrates the extent of envisaged services across Europe. It provides the foundation for the further development of hyperloop hubs and corridor locations.

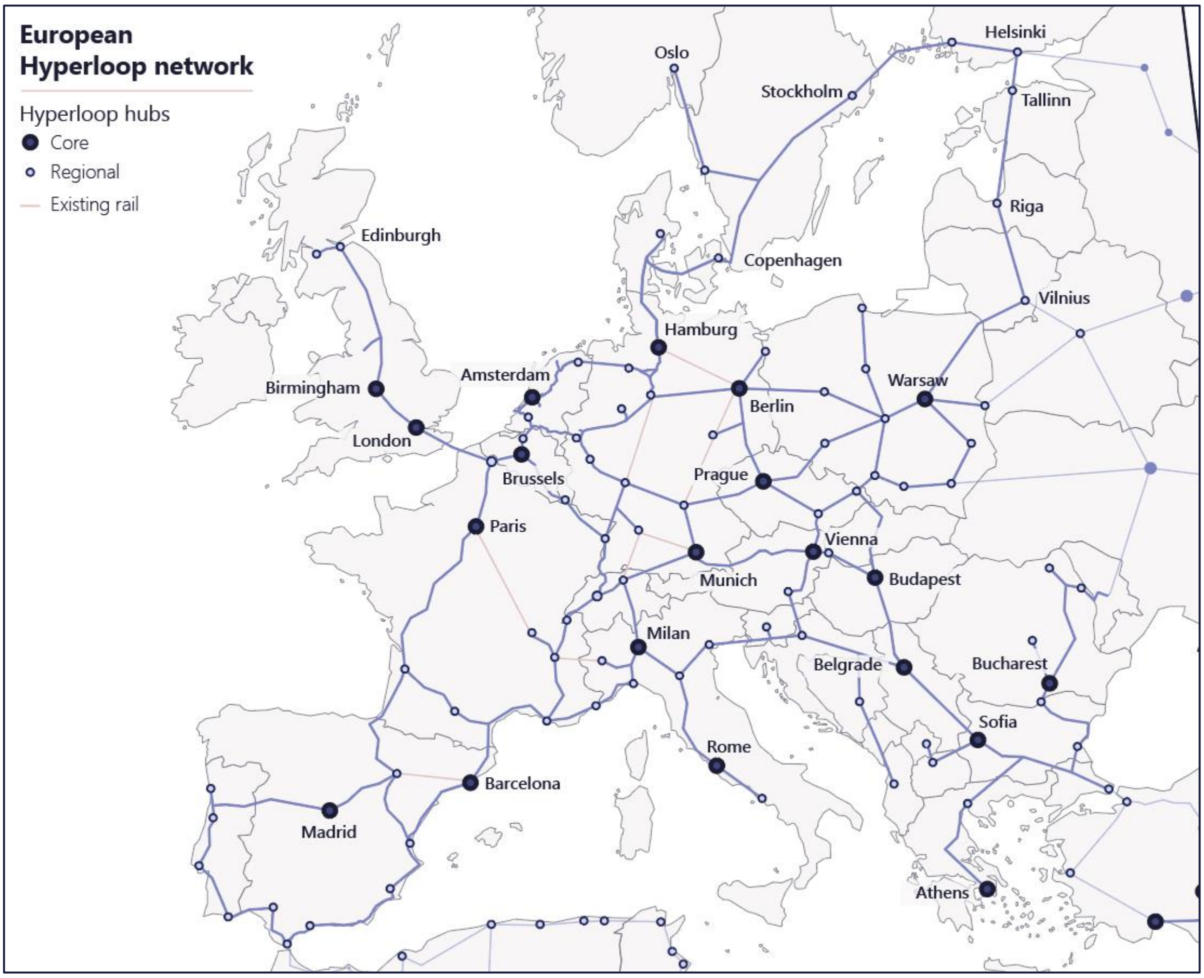


Figure 22. The European hyperloop network.

Several principles have shaped this network:

- **Integration:** the desire to integrate all major cities, airport, and maritime locations into a single commutable catchment, where day-return services between them is made possible.
- **Strategic alignment:** the need to close connectivity gaps, remove bottlenecks, and eliminate operational barriers that exist between Europe's transport networks.
- **Multimodality:** the recognition that hyperloop can play a complementary role in the future multimodal transport network.
- **Affordability:** the need to streamline the network's design to improve cost-effectiveness.

Key network facts

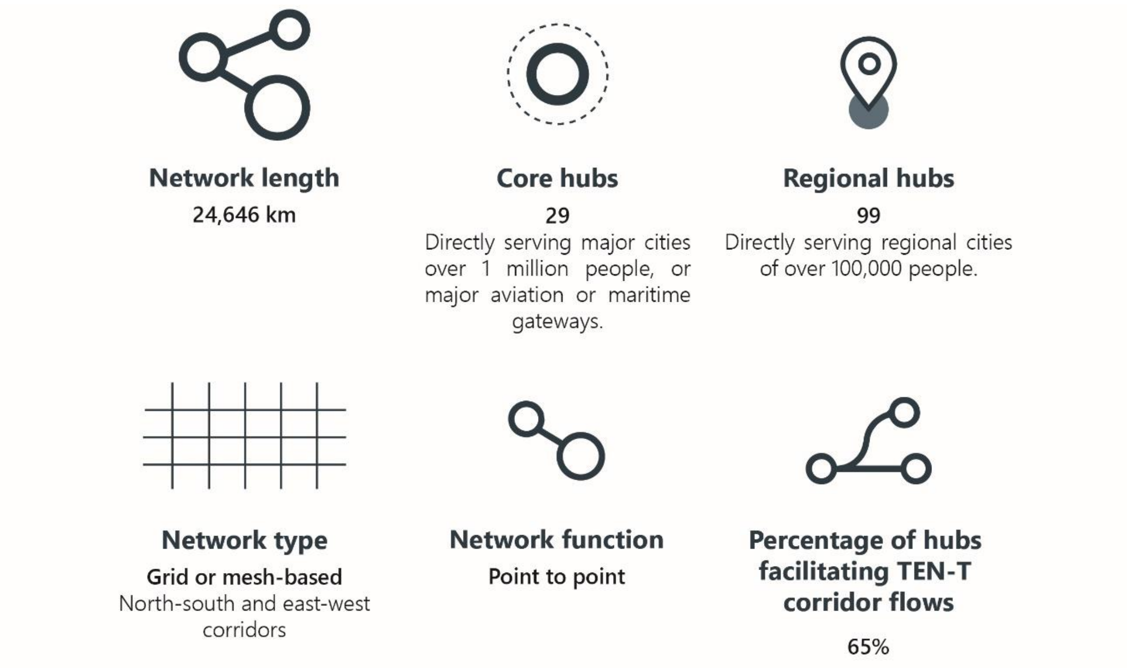


Figure 23. Key facts of the European hyperloop network.

The network sets the scene for pre-planning discussions and is subject to ongoing refinement with hyperloop development stakeholders, including national, city, and regional governments. It is anticipated that the network – along with its assumptions – will evolve over time, as more is learned about the opportunities to deliver hyperloop in local settings. If the network is progressively staged and sequenced over time, the uptake of hyperloop services is expected to be significant (this will be explored later in this report).

TEN-T policy developments

In line with the Action Plan included in the European Commission's Communication on the European Green Deal, a legislative proposal for a revision of the TEN-T Regulation was presented to the European Parliament in December 2021. The revised TEN-T Regulation is strongly focused on shifting towards cleaner, greener, and smarter mobility. At the same time, the TEN-T Regulation shows commitment to supporting and promoting hyperloop as one of the innovative technologies enabling the decarbonization of transport. The expectation is that the proposed changes to the TEN-T network will be presented for approval by mid to late 2023.

The role of sub-regions within the network

Each sub-region in Europe has a unique role to play in a Hyperconnected Europe. Some may also play a part in shaping a broader global network (full details of each sub-region can be found in a supporting document for Hyperconnected Europe). To illustrate, two examples are featured here: Central and Southeastern Europe.

Central Europe (includes Germany, Austria, and Switzerland)

Central Europe is pivotal to the success of a hyperconnected Europe. It sits at the crossroads between six of the nine corridors in the TEN-T network, forming a natural focal point for the seamless switching of services.

For example, a person on a long-distance journey from Copenhagen (in Northern Europe) to Brussels (in Western Europe) may sit in a hyperloop pod that switches at a junction in Hannover (in Central Europe), without having to change services. Therefore, it is likely to play a larger switching or through-routing role than other parts of the European network. However, it would also generate and attract trips, particularly around the 'Blue Banana' – a continuous corridor of urbanization that spreads over Central Europe, containing some of the highest GDP levels in Europe.

Southeastern Europe (includes Greece, Romania, and Bulgaria)

Southeastern Europe would be pivotal to the success of a broader, global hyperloop network. Although it sits at the edge of Europe's TEN-T network, it is at the confluence between Europe and Asia, which has the potential to carry large volumes of trans-continental passengers and freight. Turkey in particular will be critical as a trunk corridor between Europe and the Middle East, Africa, and Asia.

For example, a person on a long-distance journey from Munich (in Central Europe) to Doha (in the Middle East) may sit in a hyperloop pod that funnels through Turkey, alongside may other similar trans-continental journeys (such as London to Riyadh, or Athens to Dubai).

Southeastern Europe contains several countries that plan to be integrated into the EU, such as Serbia and Montenegro (potentially by 2025), and Albania and North Macedonia (potentially from 2025). Hyperloop may play a key role in bringing these countries into the EU through seamless (and possibly customs-free) travel between borders, growing their domestic economy and the EU single market.

Integrating hyperloop's infrastructure

The network envisaged for Hyperconnected Europe by 2050 is ambitious. Delivering the best hyperloop experiences require early consideration of how its corridors, hubs and supporting infrastructure can be effectively integrated into existing cities. It is not just about the engineering feats to achieve truly groundbreaking speeds; it is also about embracing and shaping great places across Europe.

Figure 24. An example of integrating hyperloop corridor infrastructure within existing urban settings.

Strategic guidelines for spatial integration

The spatial requirements required to deliver hyperloop services and infrastructure (such as land for construction, operations, maintenance, and placemaking), are subject to physical and regulatory constraints, particularly in dense urban settings. Many of Europe's cities feature a built legacy that will be respected and embraced when integrating hyperloop infrastructure.

To mitigate these constraints, several network design principles have been developed to assist with integration of hyperloop across Europe's cities and rural areas. The first principle is to minimize the footprint of hyperloop's tubes and hubs, creating lean infrastructure that minimizes the physical footprint. For example, hyperloop's corridor width is 8 meters, compared to 14 meters for rail, and 20 meters for a three-lane motorway (see Figure 4). The second principle is around the network typology used to service cities. Hyperloop services can reach a city in two ways. The first is by directly connecting hyperloop's core corridor to the city center. The second – the default concept – has the core corridor bypassing the city center, where a low-speed bifurcation line may reach the city center, or other key locations.

Table 4. City network typologies.

Network type	Attributes
Concept 1 – Direct connection	• Increased line length • Longer low-speed sections • Increased risk of conflicts in dense urban areas • Reduced cost-effectiveness
Concept 2 – City bypass	• Reduced line length • Shorter low-speed sections • Reduced risk of conflicts in dense urban areas • Increased cost-effectiveness

If considering the use of a city bypass (Concept 2), the typology can be configured in a variety of different ways. Some examples of city bypass configurations are tabled and illustrated below.

Table 5. City bypass configurations

City bypass configurations	Advantages	Disadvantages
Concept 2A – One hub in the center	• Well-connected by public transport • Larger catchment	• Limited provision for space • Higher costs of land acquisition • More complex delivery task
Concept 2B – Multiple hubs in the periphery	• Suitable for freight and airport connectivity • Greater provision for space • Larger catchment	• Forced interchange to local public transport services • Moderate costs of land acquisition • Moderate complexity in delivery task

Figure 25. City network Concept 2A: One hyperloop station in the center. Source: Hardt Hyperloop.

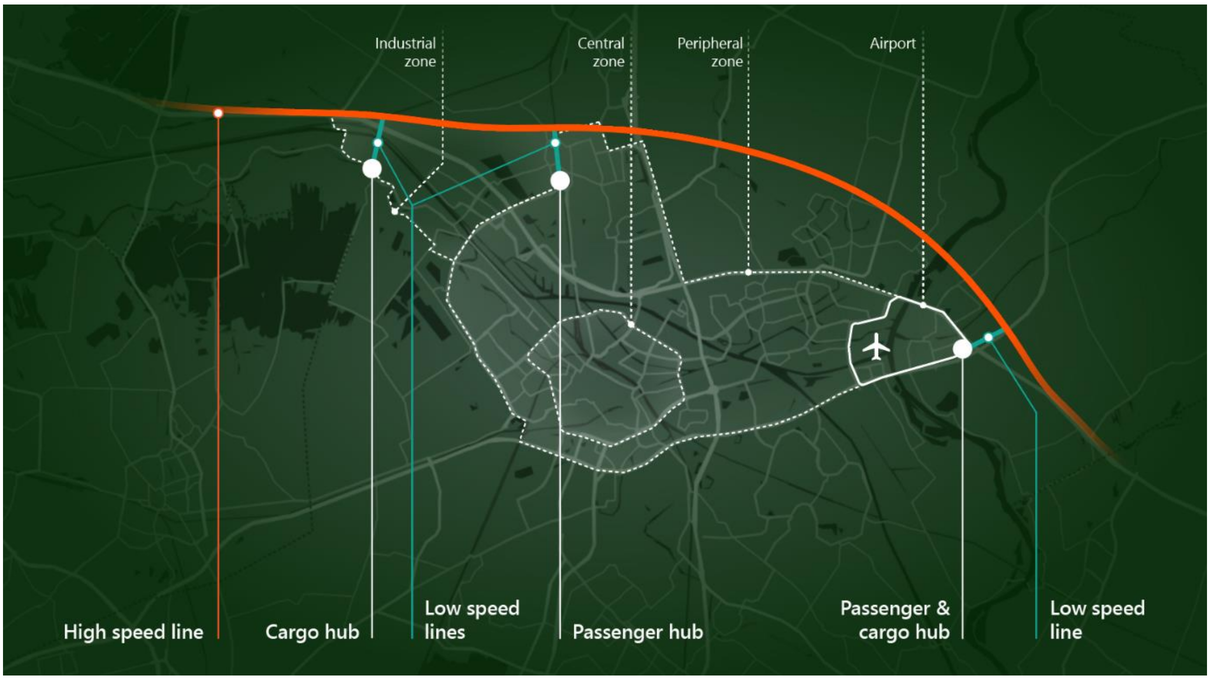


Figure 26. City network Concept 2B. Multiple hubs in the city's periphery (passenger, freight and airport hubs). Source: Hardt Hyperloop.

As pre-feasibility studies for hyperloop services progress, more of these configurations will be investigated and tested to achieve the best outcomes for each city; "there is no one-size-fits-all" approach. The figure below is an example of a tailored approach that builds on the default network concept for Hannover, Germany.

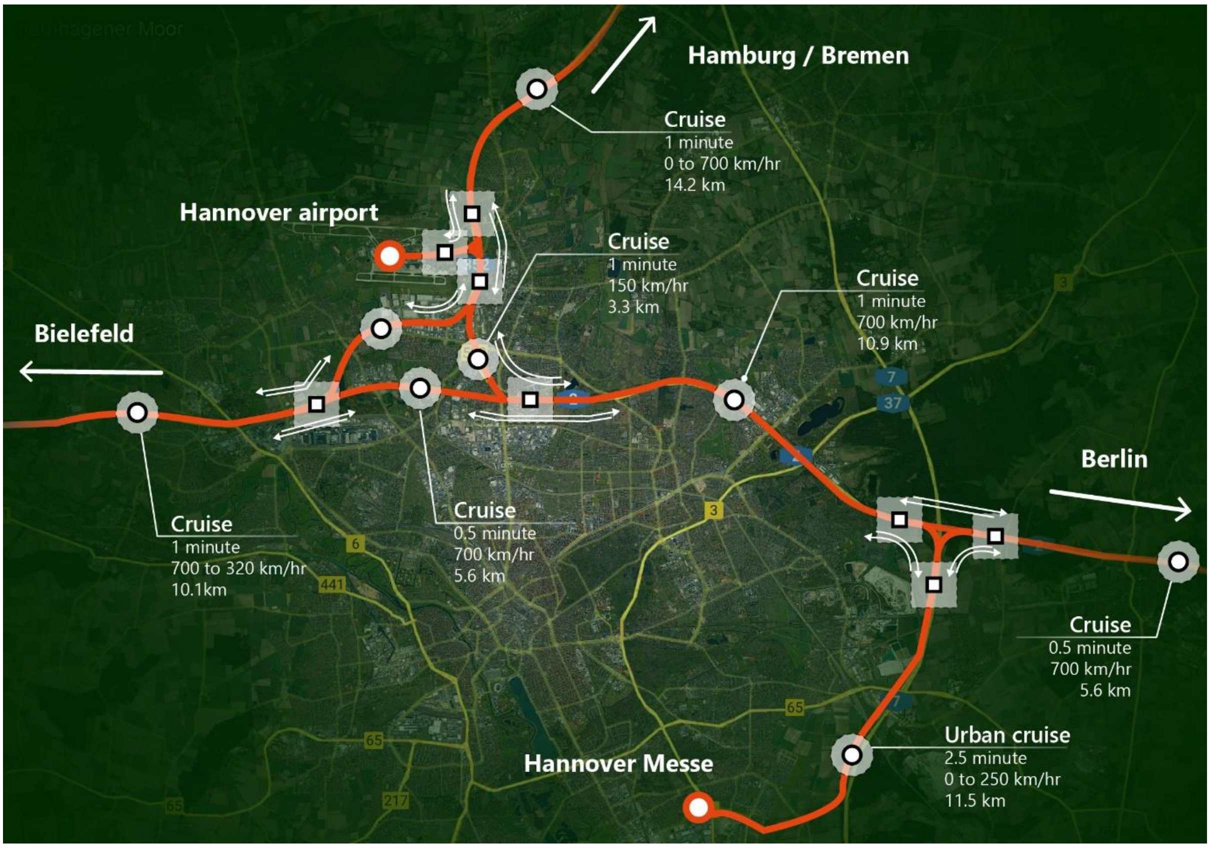


Figure 27. Application of city network concept to Hannover, Germany. Note: The concept shows that high speeds can be achieved when going around cities (by following existing highways), with lower-speed turnouts for multiple peripheral hubs (such as Hannover Airport and Hannover Messe). This alignment is indicative, subject to further investigation, and is for discussion purposes only. Source: Hardt Hyperloop.

What does this mean for European placemaking? The impact on Europe's cities and regions can be profound. Not only can hyperloop shape new cities based on sustainable livability, but it can also reshape existing cities by increasing land use development activity (at local, metropolitan, and national scales), to higher and better uses (for more on land use impacts, refer to the "Impact on Cities" chapter).

Figure 28. Hardt Hyperloop hub. Design by UNStudio. Render by Plomp.

Hyperloop represents an exciting opportunity to bring together private sector expertise with the foremost experts in city planning to plan for great public, community, residential and commercial spaces. Places that can drive growth and investment opportunities and delight the people who live or visit them.

Speed and travel time performance

Hyperloop is capable of operating at cruising speeds of over 700 kilometers per hour. Achieving these speeds is possible in relatively straight sections of corridor, across a flat landscape. Segments of the network in sparsely populated areas allow for higher operational speeds (as the alignment will face fewer obstacles or constraints). Conversely, in more urbanized areas, lower average speeds are likely, as the alignment may feature more turns to avoid physical constraints or integrate with existing interfaces.

The Hyperloop Development Program (HDP) has calculated several segments of the European network where average speeds of 500 kilometers is achievable (subject to further investigation). These speeds have been applied to estimate the travel time between the following supporting cities and regions of Hyperconnected Europe (see table below):

Table 6. Estimated travel times between Hyperconnected Europe's supporting cities.

Travel time in minutes	Amsterdam	Antwerp	Berlin	Brasov	Gibraltar - Algeciras	Groningen	Munich	Rotterdam	Rzeszow	Zaragoza
Amsterdam		00:25 hr	1:30 hr	06:27 hr	05:06 hr	00:27 hr	01:43 hr	0:11 hr	03:35 hr	03:04 hr
Antwerp	00:25 hr		01:27 hr	06:16 hr	04:44 hr	00:48 hr	01:32 hr	00:18 hr	03:24 hr	02:43 hr
Berlin	01:30 hr	01:27 hr		05:40 hr	06:06 hr	01:07 hr	01:25 hr	01:31 hr	02:17 hr	04:06 hr
Brasov	06:27 hr	06:16 hr	05:40 hr		08:49 hr	06:44 hr	04:48 hr	06:20 hr	03:27 hr	07:50 hr
Gibraltar - Algeciras	05:06 hr	04:44 hr	06:06 hr	08:49 hr		05:29 hr	04:45 hr	04:59 hr	06:39 hr	02:05 hr
Groningen	00:27 hr	00:48 hr	01:07 hr	06:44 hr	05:29 hr		02:06 hr	00:34 hr	03:21 hr	03:27 hr
Munich	01:43 hr	01:32 hr	01:25 hr	04:48 hr	04:45 hr	02:06 hr		01:36 hr	01:58 hr	03:46 hr
Rotterdam	00:11 hr	00:18 hr	01:31 hr	06:20 hr	04:59 hr	00:34 hr	01:36 hr		03:28 hr	02:57 hr
Rzeszow	3:35 hr	03:24 hr	02:17 hr	03:27 hr	06:39 hr	03:21 hr	01:58 hr	03:28 hr		05:40 hr
Zaragoza	03:04 hr	02:43 hr	04:06 hr	07:50 hr	02:05 hr	03:27 hr	03:46 hr	02:57 hr	05:40 hr	

Key travel time benefits include:

- Amsterdam to Groningen in 27 minutes.
- Groningen to Munich in 2 hours and 6 minutes.
- Rzeszow to Berlin in 2 hours and 17 minutes.
- Zaragoza to Antwerp in 2 hours and 43 minutes.

Estimating strategic benefits and costs

The benefits of realizing hyperloop transport in Europe are profound. This chapter looks at preliminary assessments and insights into the forecast demand for future hyperloop services, the whole-of-life cost estimates for hyperloop's infrastructure and services, and quantifies some of the benefits people, businesses, and policymakers can expect from full network realization.

Forecasting passenger demand

For the passenger market, the first consideration is to model the anticipated uptake of hyperloop services, as if it were integrated into the future transport network (alongside cars, buses, rail, and aviation).

In 2050, hyperloop is expected to serve an estimated 1.32 billion passenger trips and 1.31 trillion passenger kilometers (see figure below).

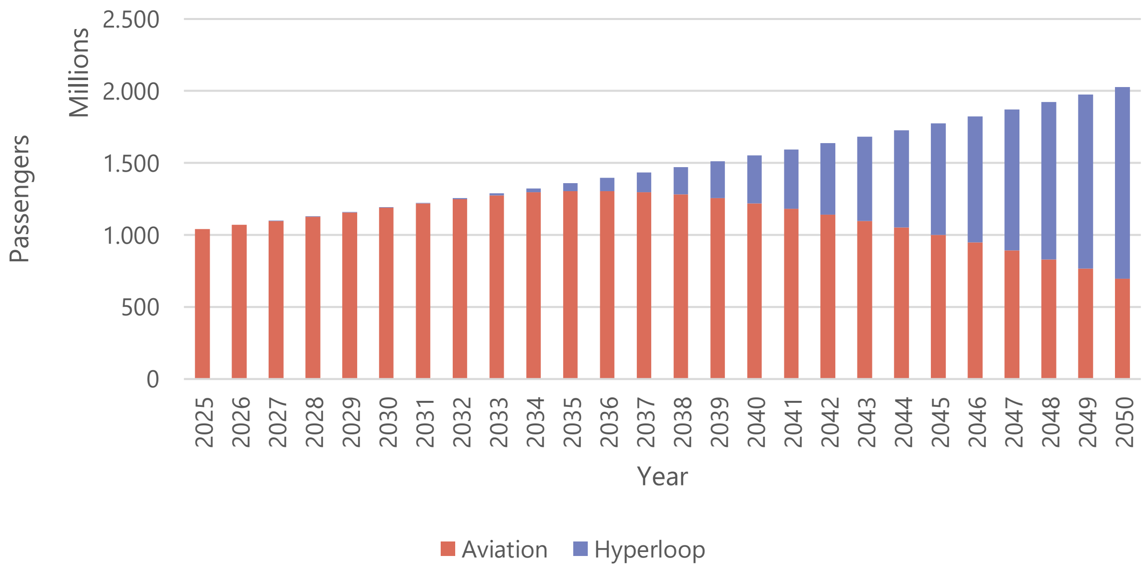


Figure 29. Annual passengers transported per mode.

The estimation is based on an average modal shift of 66 percent from aviation towards hyperloop. The modal shift is calculated based only on door-to-door travel time and has been applied uniformly on the European routes applicable to hyperloop.

How are demand volumes estimated?

Data from the International Air Transport Association (IATA) of seats between airports in 2019 using an occupancy rate of 86% was used to model aviation demand. According to a forecast by the International Civil Aviation Organization (ICAO), aviation demand is expected to grow by 2.7 percent annually[1] towards 2050.

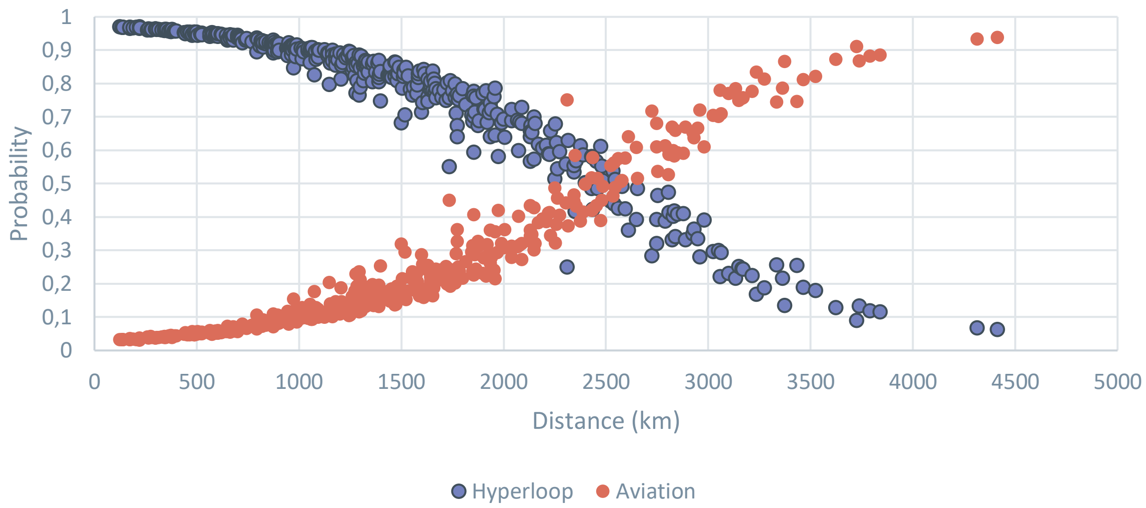


Figure 30. Probability to choose hyperloop or aviation for various European O-D pairs

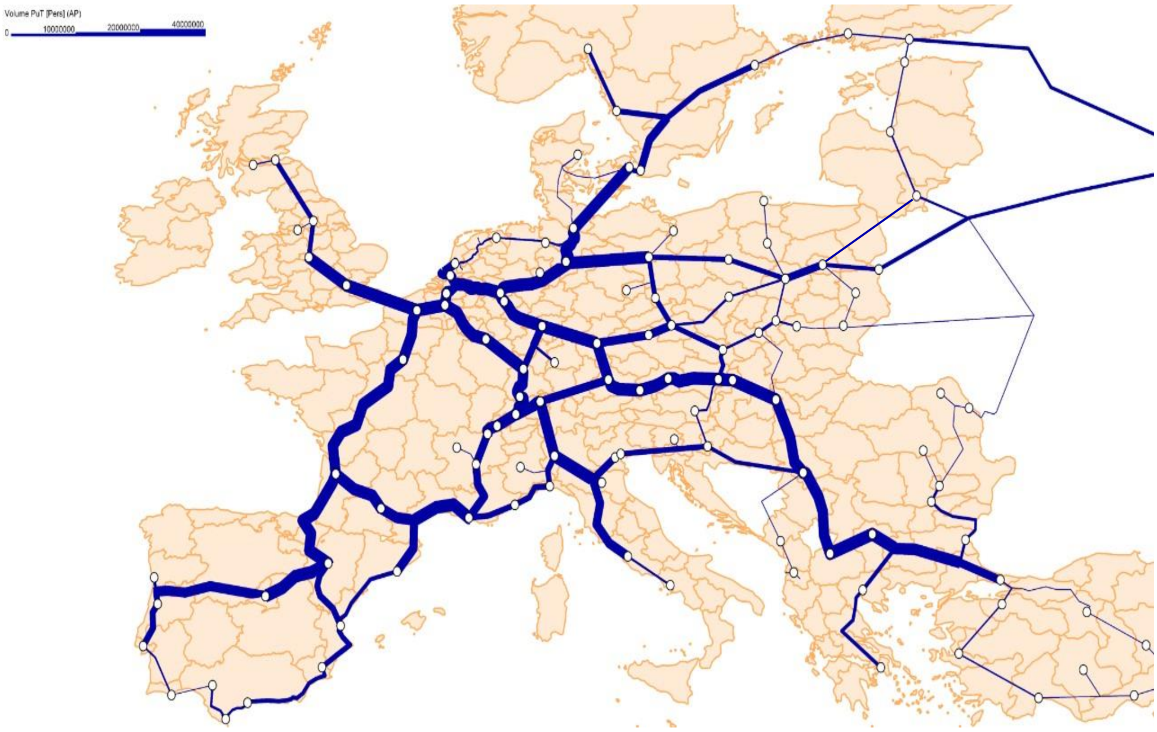


Figure 31. Preliminary traffic volumes of a hyperloop network generated by Hardt Hyperloop's "VESSEL".

This assessment is preliminary and has yet to take into account further refinements to align with context-specific policy scenarios, such as developing multimodal synergies with high-speed rail, or replacing targeted short-haul flights. Hyperloop's infrastructure and services could be further optimized, to encourage mode shift away from cars and trucks.

Further scenario-testing could also evaluate the impact of hyperloop performing different roles in the overall transport network, for example, determining the optimal extent to which it could provide relief or growth to metropolitan or regional transport networks.

The network's development is expected to accelerate over time, as governments and industry become familiar with hyperloop's transport benefits and construction methods. The delivery of the full European network could be achieved by the 2050s.

Forecasting freight demand

The share of goods likely to be moved by hyperloop depends on the type of goods and what the value of time is. Time-sensitive goods, high-value goods, and orders through e-commerce are more likely to shift from trucks to hyperloop.

Long-haul truck trips of more than 300 kilometers are considered when forecasting freight demand for hyperloop; this is regarded the minimum for "day-return" services of this type (e-truck distances are likely to be lower). This assessment estimates that long-haul truck movements in the EU could be reduced by 19 percent by 2050, while total truck movements could be reduced by around 6 percent.

Similar to forecasting passenger demand, this estimation is preliminary, and optimizations can be made to further reduce long-haul truck movements. The effectiveness of hyperloop is also dependent on the location of its freight hubs. By integrating them within supply and demand centers, or within distribution centers along a city's periphery, hyperloop can reduce the number of inbound truck movements, whilst allowing last-mile deliveries to be facilitated through light vehicles (such as courier vans).

		2050 annual volume and impact:
Truck	• Only long haul trucking considered (>300 km) • 80% of 'best fit' products *(time sensitive goods such as fresh goods)* • 30% of 'good fit' products *(e.g. high value goods)* • 5% of other goods	*620 million tonnes of freight from trucking* *384 billion tonne-km* *19% of long haul truck traffic* *6% of all truck traffic*
Air	• All continental air freight and mail flows considered 'best fit' products • 80% moved to hyperloop	*5.2 million tonnes of air freight* *5 billion tonne-km*
Ship	• Not included (containerized and non-time critical)	
Rail	• Not included (containerized and non-time critical)	

Figure 32. Hyperloop freight demand assessment (annual volume and impact in 2050). Note: Estimates are based on Eurostat 2019 data.

By 2050, 625 million tonnes respectively 389 billion tonne-km of freight could be transported by hyperloop (see figure below).

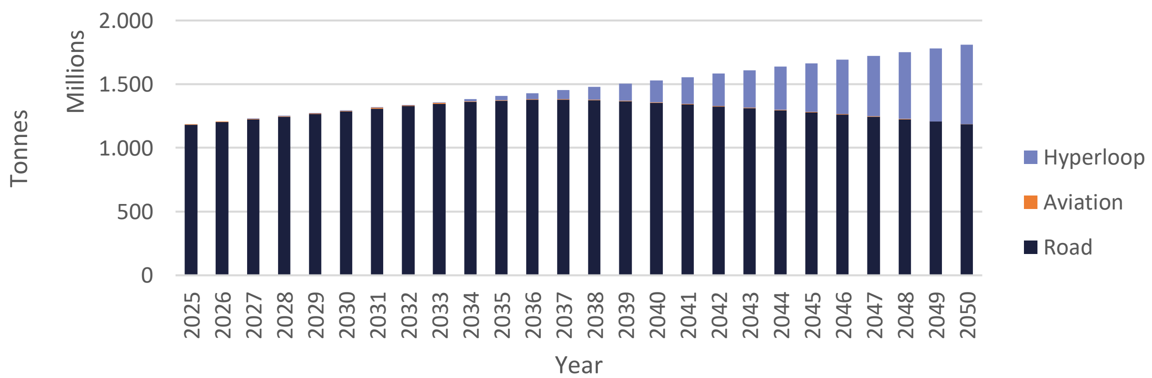


Figure 33. Annual tonnes of long-distance freight transported per mode. Aviation freight flows are less than 1 percent of road freight flows and therefore barely visible in the graph.

Implications for existing modes

The realization of a full hyperloop network by 2060 will have implications for the mode share of existing services. Hyperconnected Europe's mode share research suggests that:

- **For aviation:** The amount of passenger kilometers travelled may decline by around 70 percent for intra-European aviation.
- **For rail:** No modal shift between rail and hyperloop has been assumed in the study. A factor to consider is that hyperloop and rail could complement each other by shifting passengers from rail to hyperloop and thereby freeing up capacity for containerized or intermodal freight transport on rail. Hence, hyperloop could also improve the overall modal shift from road to more sustainable modalities. Conversely, the introduction of hyperloop could increase the overall number of passengers choosing for public transport, where rail could serve as a feeder to the hyperloop network, and therefore increase modal share of rail for passengers.
- **For on-road transport:** Currently, only the shift from long-distance truck transport has been considered, which may reduce pressure on the roads. Additionally, the introduction of hyperloop could increase the overall number of passengers choosing for public transport, and therefore decrease the modal share of road transport.

Estimating hyperloop benefits

The next consideration (after forecasting demand) is to estimate the benefits that hyperloop technologies can bring to people and places across Europe. The range of potential benefits include:

- **Transport benefits:** For example, travel time savings, punctuality, reliability, convenience, and comfort factors.
- **Economic benefits**: For example, jobs created directly through hyperloop construction, economic clustering, commuter trips induced by hyperloop services, and congestion relief.
- **Social benefits:** For example, placemaking, socioeconomic integration, and mode shift from cars, trucks, and flights towards active and public transport.
- **Land use benefits:** For example, avoided infrastructure costs through urban densification, city-shaping, urban regeneration, and mixed-use planning opportunities.
- **Sustainability benefits:** For example, greenhouse gas emissions saved through hyperloop use, reductions in car or truck vehicle kilometers travelled (VKT), and reductions in noise emissions.
- **Safety benefits:** For example, reduced road accidents due to mode shifts to hyperloop.

Strategic benefits are estimated through an impact assessment that considers two future scenarios where hyperloop is introduced (see table below). The first scenario, "AS IS", measures a range of impacts from today's perspective. The second scenario, "IMPROVED", applies an improvement factor for all modes of transport to account for improvements related to, for example, technological advancements, energy efficiencies, and new production processes over time.

In 2050, the Hyperconnected Europe network can generate between €192 and €294 billion in potential benefits.

Table 7. Estimation of hyperloop's impacts under "AS IS" and "IMPROVED" scenarios.

Scenario (non-discounted values for year 2050 in billion €)	"AS IS"	"IMPROVED"
Accidents	5.9	5.9
Air – freight	*0.0*	*0.0*
Air – passenger	*0.6*	*0.6*
Road – freight	*5.4*	*5.4*
Air pollution	7.2	3.7
Air – passenger	*4.2*	*1.6*
Road – freight	*3.1*	*2.1*
Climate: hyperloop	-21.3	-1.7
Climate: other modes	193.5	90.1
Air	*154.2*	*63.1*
Road	*39.3*	*26.9*
Congestion (Road – freight)	0.8	0.8
Noise	8.8	4.0
Air – freight	*0.0*	*0.0*
Air – passenger	*6.4*	*2.4*
Road – freight	*2.3*	*1.6*
Reliability (Road – freight)	36.3	36.3
Time	46.8	46.8
Air – passenger	*3.4*	*3.4*
Road – freight	*43.4*	*43.4*
Well-to-tank emissions	15.5	6.1
Air – passenger	*14.7*	*5.6*
Road - freight	*0.8*	*0.5*
Net impact	293.6	192.0

Note: This impact analysis is indicative and subject to further assessment

The production processes and construction of hyperloop infrastructure, and "day-to-day" operations contribute to negative impacts (emissions), which is estimated and accounted for as costs. Nevertheless, by 2050, a net emissions reduction of between 0.6 and 1.1 billion tonnes of CO_2 is expected (see figure below).

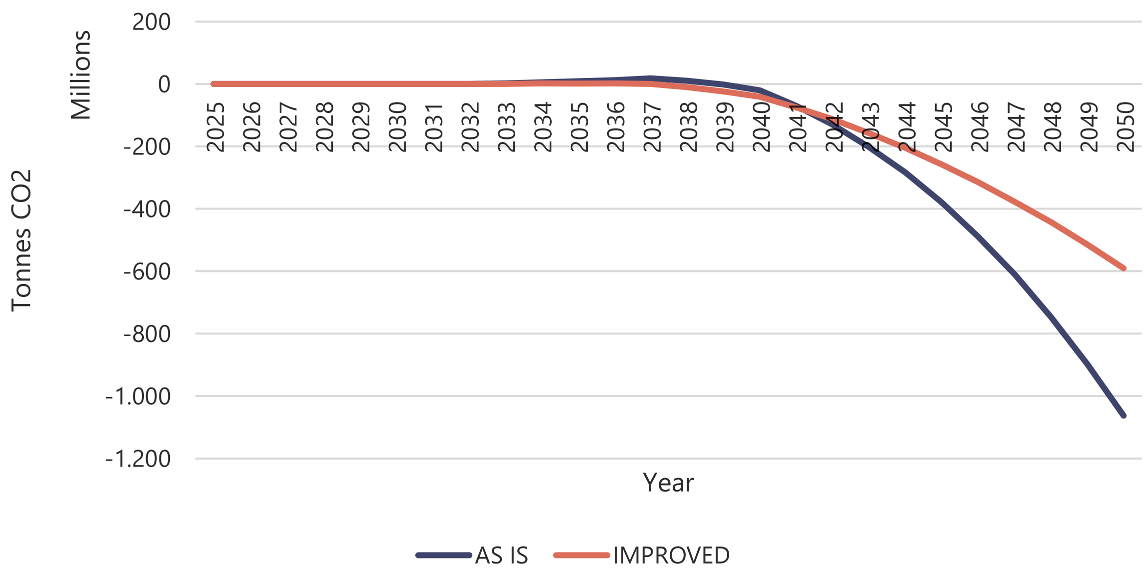


Figure 34. Cumulative net CO_2 emissions for European hyperloop system construction and operations.

Estimating hyperloop costs

The capital costs of realizing a vast hyperloop network are significant (see table below). The strategic cost estimates of delivering the full Hyperconnected Europe network by 2050 is estimated at €981 billion (in 2022 values). Compared to the investment forecasts needed for existing transport modes (see chapter: "The European transport challenge"), this would represent a share of 10.1 percent. Thus, by reapportioning some of the funds towards hyperloop implementation, a comprehensive European network could be realized, and offer an "order-of-magnitude" realization of benefits described earlier in this chapter (transport, economic, social, land use, sustainability, and safety benefits).

Table 8. Strategic estimates of capital costs required to deliver the full European hyperloop network.

Capital expenditure category	Costs (in billion €)
Corridor infrastructure	524
Hubs	233
Vehicles	46
Other costs	88
Contingency	89
Total	**981**

The operational costs of hyperloop are minimized because of the use of magnetic levitation technology, fully autonomous operations (similar to rail's 4th grade of automation), and tubes that allow vehicles to operate in a fully enclosed environment, shieled from external weather (see table below).

Table 9. Strategic estimates of operational costs for the full European hyperloop network (in 2050).

Operational expenditure category	Costs in 2050 (non-discounted values, in billion €)
Infrastructure maintenance	2.2
Insurance	2.4
Selling, general and administrative costs	34.1
Energy: infrastructure and vehicles	9.4
Total	**48.1**

Estimating hyperloop revenues

For the transportation of freight by hyperloop a price of €0.13 per tonne-km is assumed, which is the average price charged for trucking across Europe. For passengers an average price of €0.15 per passenger-km is assumed, which is competitive in pricing to existing modes of transportation.

Table 10. Estimates of the revenues for hyperloop passenger and freight services (in 2050).

Revenue Category	Value in 2050 (non-discounted values, in billion €)
Hyperloop freight services	50.6
Hyperloop passenger services	197.8
Total	**248.4**

The impact on European cities

Figure 35. The hyperloop passenger experience.

With over 70 percent of EU citizens living in urban areas, urban and inter-urban mobility outcomes can have a considerable influence on their quality of life. Yet gridlock, poor air quality, and inefficient transport continues to impact on the lives of people across the continent[7]. Reliable, affordable, and safe public transport is key to achieving sustainable mobility in cities. It can lower emissions, energy consumption, and reduce congestion, thereby improving traffic flows and reducing travel times. Cities have a unique opportunity to provide optimized and efficient public transport networks to meet citizens' needs[8]. Hyperloop has the potential to bring people and goods in and out of European cities at high capacity, while reducing the space and energy requirements needed to do so.

Improved livability outcomes

According to the EU's Joint Research Centre in 2019 (JRC), European cities will look profoundly different in the future. It found that:

- Most European cities will grow and recognize the importance of organizing their urban space.
- EU cities will have to deal with the needs of an increasingly older population, which is wealthier, and more mobile.
- Cities are becoming increasingly technological, offering opportunities for more connectivity, but also bring the risk of increased social exclusion.
- The dominance of cars should be drastically reduced in favor of more efficient public transport.
- Cities should provide sufficient affordable housing while guarding inclusiveness.
- Growing cities will become denser, with new neighborhoods being more sustainable and 'self-contained' than existing suburbs.

[7] SUMPs-Up: https://sumps-up.eu/home/

[8] European Commission – The Future of Cities: https://publications.jrc.ec.europa.eu/repository/handle/JRC116711

Hyperloop will respond to these challenges and contribute towards improved livability outcomes (see figure below). It can facilitate sustainable and inclusive growth, reduce car dependency, and distribute wealth more equitably across the EU.

01 REDUCED LAND USE

Challenge:
Transport occupies 10-25% of urban space.

Solution:
Hyperloop uses less than 50% of the space that road/rail/metro uses for the same transport capacity.

02 IMPROVED CONNECTIVITY

Challenge:
Insufficient connectivity drives up housing prices and supply chain inefficiencies.

Solution:
Hyperloop connects urban centers up to 300 km away within 30 minutes, providing agglomeration effects.

03 IMPROVED TRANSPORT CAPACITY

Challenge:
Current infrastructure cannot accommodate the growth in demand of 250% towards 2050.

Solution:
Hyperloop provides transport capacity of over 20,000 passengers or 10,000 pallets per hour per direction.

04 IMPROVED RELIABILITY

Challenge:
The cost of road congestion in the EU is over €100 billion per year.

Solution:
Hyperloop is immune to external influences and leaves no room for human error, ensuring minimal delays.

05 IMPROVED SAFETY

Challenge:
Each year, 1.35 million people are killed on roadways around the world.

Solution:
With autonomous operations and no mixed traffic, hyperloop has the potential to be the safest transport system.

06 REDUCED INVESTMENT NEED

Challenge:
€50 trillion is required to accommodate demand with traditional modalities.

Solution:
Hyperloop provides the highest capacity per investment with 20,000 passengers per hour per direction for ~€30 million / km.

07 REDUCED GHG EMISSIONS

Challenge:
Transport accounts for 23% of greenhouse gases.

Solution:
Hyperloop emits no direct emissions and can be powered by green electricity.

08 REDUCED NITROGEN EMISSIONS

Challenge:
Transport accounts for 67% of all NOx emissions.

Solution:
Hyperloop emits no direct emissions.

09 REDUCED POLLUTION

Challenge:
Transport accounts for 10% of all pollution.

Solution:
Hyperloop emits no pollution.

10 REDUCED ENERGY USE

Challenge:
Transport energy use will grow by 70% towards 2050.

Solution:
Hyperloop uses 10 times less energy than road or aviation.

11 REDUCED NOISE POLLUTION

Challenge:
25% of EU population is exposed to unacceptable noise and vibration levels.

Solution:
Hyperloop produces insignificant noise and vibrations.

12 REDUCED MAINTENANCE COST

Challenge:
50% of infrastructure investment is lost to maintenance.

Solution:
With no moving components in the infrastructure and frictionless travel, hyperloop has limited maintenance cost.

Figure 36. Benefits of hyperloop. Source: Hardt Hyperloop

Transformed competitiveness

The debate on how to improve Europe's external competitiveness is a perennial one. A variety of statistics show that it has been eroding for some time. Productivity gains in other global economies have generally been higher than the EU, while the export market shares of EU's largest economies have declined steadily over the past two decades. Admittedly, the higher rates of productivity growth recorded by emerging market economies are due in part to the relatively low starting levels for productivity and the catch-up effect, as they absorb technology and attract capital from wealthier nations.

By improving connectivity between European cities, it can function as one tightly knit city cluster, one expansive and green metropolis. By building seamless cross-border connections between EU countries, the single market would be completed.

Business and leisure travelers would be able to travel effortlessly and sustainably across borders. Goods would move across Europe within hours, becoming more efficient and on-time for consumers. Social interactions between the residents of member states are crucial to improving mutual understandings, and to battle polarization. Reducing international travel to meet Green Deal goals is therefore not a desired pathway, as it would not only increase the physical distance between Europeans, but also intellectual and cultural distance. Travelling within a more integrated EU has led to greater socioeconomic cohesion, and a strengthened European identity[9].

Figure 37. Hyperloop allows for the facilitation of an expanded European single market.

[9] European Commission – Sustainable and Smart Mobility Strategy: https://eur-lex.europa.eu/resource.html?uri=cellar:5e601657-3b06-11eb-b27b-01aa75ed71a1.0001.02/DOC_1&format=PDF

The road to realization

Hyperloop is developing quickly and is expected to reach commercial readiness over the next five years. To achieve this, several hyperloop technology providers are in the process of building test facilities, collaborating on system standardization, and performing tests. The Hyperloop Development Program is currently building the European Hyperloop Center in the province of Groningen and is expected to conduct the first tests from late 2023.

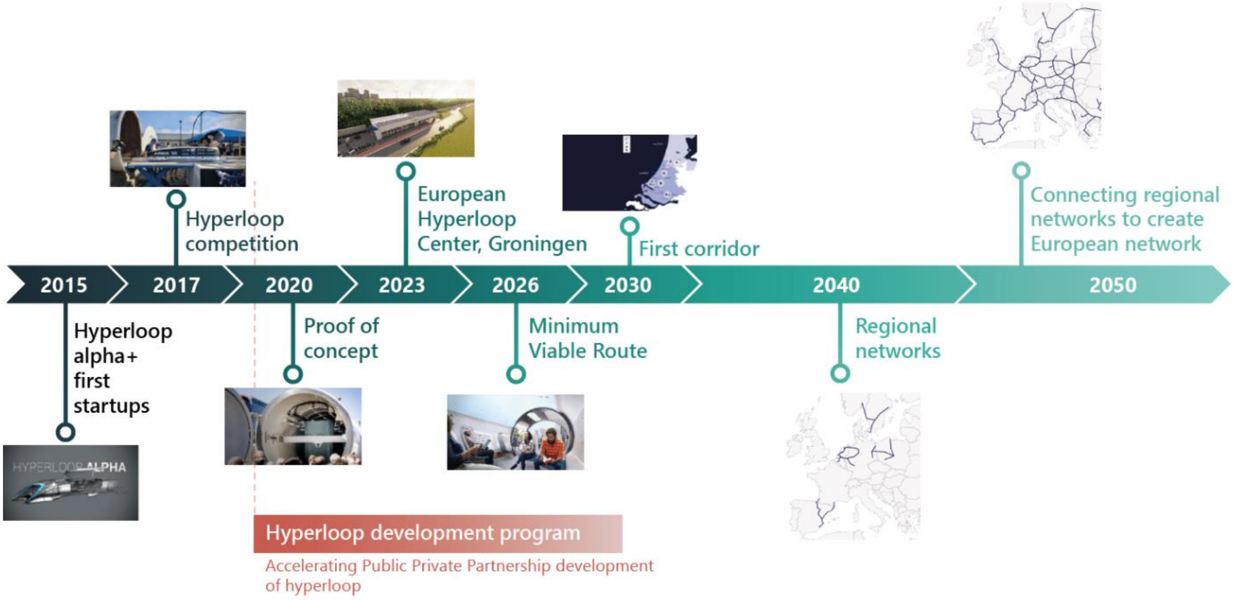


Figure 38. Timeline of hyperloop implementation.

Early route and network development strategy

Between now and the testing phase, pilot routes are being identified and assessed across Europe. From the second half of the 2020s, it is envisaged that the first routes will be implemented over a short distance (between three and thirty kilometers in line length). Such a route can be delivered either for freight or passenger operations with limited complexity – for example, an airport to city center connector, with one or two integrated freight hubs. It will serve a transport need, as well as act as a catalytic project to demonstrate its features to stakeholders and accelerate public acceptance.

From the 2030s, hyperloop will be expanded to create broader networks for freight and passengers over longer distances, creating regional networks across Europe. These regional networks will then be connected together over the 2040s to create one pan-European network by the 2050s.

What city and regional governments can do

Realizing the European hyperloop network may seem like a long-term endeavor. However, to make it happen over time, and to tackle the European Green Deal goal of climate neutrality by 2050, governments of all levels should now consider and position hyperloop as an alternative to investments in conventional modes of transport.

Cities, regions, and its citizens are the ultimate beneficiaries of hyperloop, and they can push the policy agenda for infrastructure investments as a public good. Local and regional governments are struggling with zero-emission ambitions in transport, while maintaining a level of mobility that would keep their inhabitants happy, healthy, and prosperous.

Realization Roadmap Europe by HDP partner Berenschot Consultants

"The success of hyperloop technologies is dependent on an asset-heavy backbone for which technologies are currently being developed. Once it is operational, a hyperloop network has the potential to change the mobility and transport domain. However, moving it from a novelty into a modality that connects regions and cities, requires extensive investments and broad public acceptance. Since both will be supplied in large measure by stakeholders from governments and various public arenas, it is essential to have long term socio-political buy-in on a solid proposal whose contributions to collective goals are well understood. This can be facilitated by a well-defined roadmap with explicit scenarios, actions, and timelines.

Big infrastructural projects are generally only realized when they solve a socio-economic problem. This is especially true for projects whose finance and planning budgets are influenced by high levels of uncertainty. As guidelines and standards for freight solutions are not as stringent as those for passenger services, it is sensible to start transporting freight with hyperloop technologies, to be followed by passenger transport.

Cities are looking for more and new ways to keep their centers livable. With increasing urbanization and the growing call for urban sustainability (amongst which cleaner air, safer streets, and less fossil-fueled traffic), moving freight from highways to hyperloop makes a lot of sense. By reducing the amount of freight that needs to share road capacity with other motorized transport, negative effects can be minimized while the needs of smart and sustainable cities can be met. This might require significant de-investments in legacy systems (such as distribution systems that cannot properly be interfaced with a hyperloop network) and major changes to business processes (such as those in supply chains). In that respect, it helps when there's a clear call for change from politics and society.

Freight hyperloop services can pave the way for commercial passenger services, while at the same time allowing for maturation of the hyperloop ecosystem. For this to materialize, it is essential that multiple regions co-develop strategies for logistics and transport. The success of a network depends on its connections and nodes, and the ease with which they can connect socio-economic centers is significant to their adoption. That requires, for example, integration of hyperloop infrastructure in urban planning, finding ways to link urban centers to hubs and developing a common public understanding for the reason to do both.

Furthermore, although the technological concept can be proven by one single connection locally, it takes pan-European cooperation and coordination to realize a proficient network. Currently, many hyperloop companies are advocating for their own concepts of infrastructure, technology, service model and development trajectories. Although this is not uncommon for new technologies, it is important that universal standards are developed and adopted sector-wide to ensure prompt adoption."

Expanding Hyperconnected Europe

As of June 2022, the following city and regional governments have signed the Letter of Support for Hyperconnected Europe:

- Algeciras
- Berlin
- Brasov
- Flanders
- Groningen
- Munich
- North Holland
- Rotterdam
- Rzeszow
- Zaragoza

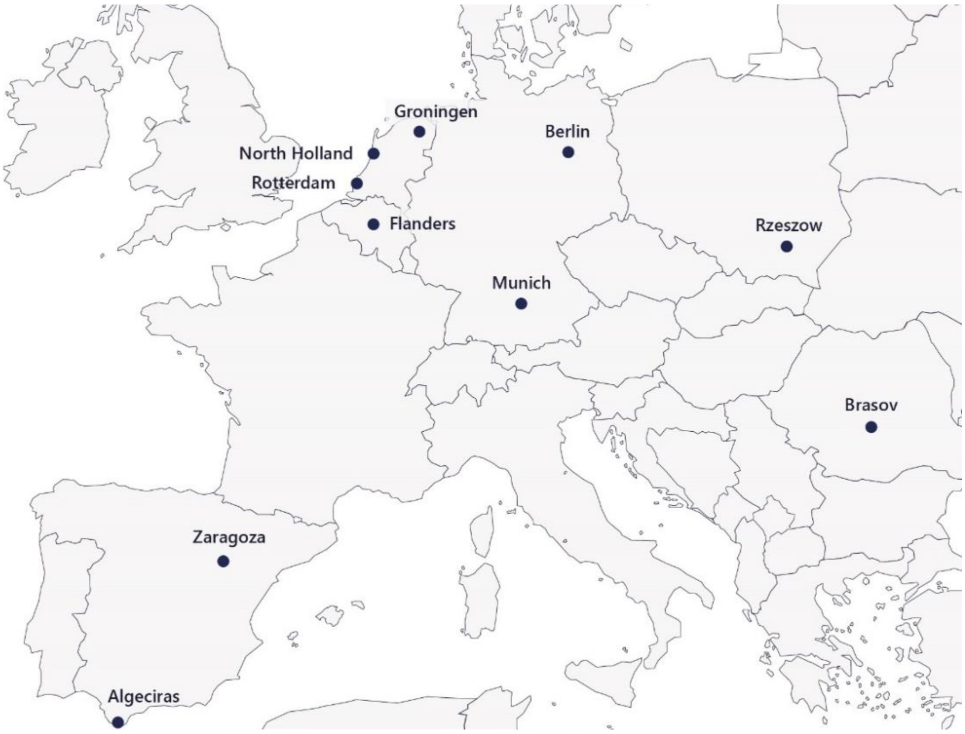


Figure 39. Hyperconnected Europe's supporting cities and regions, as of June 2022.

These governments have indicated their willingness to think about the potential of a European hyperloop network to help facilitate sustainable growth, and to express their interest in hyperloop as an emerging mode of transport. Moving forward, this community will be expanded, with more topics to be explored in the coming months and years:

1. Economic impact.
2. Social adoption.
3. Safety concepts.
4. European roadmap.
5. Regional implementation.
6. Initial routes and corridors.

In the next phase of Hyperconnected Europe, the Hyperloop Development Program will organize regional workshops with supporting cities and other European authorities that will join to support the initiative.

Any city or region in Europe is invited to participate, and there are no costs associated with the support for Hyperconnected Europe. For more information on joining the initiative, upcoming events, and access to research, please visit:

www.hyperconnected.eu

Figure 40. Hyperconnected Europe's supporting cities and regions, as of June 2022.