

ACCELERATING TOWARDS A SUSTAINABLY CONNECTED EUROPE

The transformative potential of hyperloop

SETTING THE HYPERLOOP STAGE

Europe is facing several transitions: toward a greener economy, greater connectivity, and strategic autonomy. Innovative solutions are needed to meet these challenges. The hyperloop offers an opportunity to support these transitions with a vision for a sustainably connected Europe.

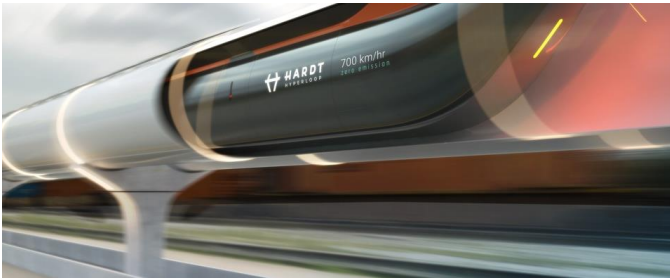


Figure 1 - Render of a hyperloop

The transport transition requires new approaches, as existing modes of transport fall short in several areas. Airplanes will always require substantial amounts of energy and release aerosols at high altitudes even when decarbonized. Traditional railways, despite being more energy-efficient, are not fast enough for long distances. Additionally, current transport modes have inherent issues such as noise, high land-use, maintenance costs, and vulnerability to weather disruptions, which all limit their effectiveness in meeting Europe's long-term goals.

The hyperloop is an innovative transportation system that moves passengers and cargo in low-pressure tubes using magnetic levitation and traction. It combines speeds comparable to air travel with the energy efficiency and convenience of rail. With the potential to connect most European cities within three hours, the hyperloop promotes deep interregional integration. It is hard to imagine a solution more closely aligned with Europe's goals for technological leadership, sustainability, and cohesion than the hyperloop.

Backed by the European Commission in a cross-border collaboration and already in testing, hyperloop is progressing toward deployment. International partnerships are developing a harmonized system, common standards, and coordinated development and test strategies. Significant progress has been made, but much work remains to be done.



Figure 2 - Passengers in a hyperloop test (Munich, Germany)

While there are challenges and concerns around cost, regulatory hurdles, safety, and technological maturity—which are valid and must be addressed—the impact of hyperloop is too important not to pursue. With multiple European policies and strategic reports explicitly calling for hyperloop, Europe must embrace and support this innovation and leverage collaboration to make it a reality.

This paper describes the transformative potential of the hyperloop and outlines the steps needed to turn the vision into reality. By building on the momentum around hyperloop, Europe can pioneer a new form of high-speed travel, establishing a dynamic new industry and bringing Europeans closer together.

THE BENEFITS OF HYPERLOOP

Lowest energy consumption and emissions: The low-pressure tube virtually eliminates aerodynamic resistance, the primary cause of energy use in air, rail, and road transport. 100% powered by electricity—a large fraction of which can be generated by solar panels on its own infrastructure—hyperloop has zero operational emissions.

High speeds: Magnetic levitation ensures that the vehicles never touch the rails, eliminating wear and tear and allowing cruise speeds of 700 km/h and beyond. This speed allows hyperloop to replace polluting short-haul flights over distances up to approximately 2,000 km.

Low environmental impact: Without direct contact and air to transmit sound, hyperloop is a silent mode that can be integrated into any environment. The compact infrastructure also uses little land.



Figure 3 - A hyperloop integrated in the landscape through art painted in the tube (Groningen, The Netherlands)

Scalable and flexible infrastructure: The modular design of hyperloop tubes supports efficient scaling of the network. Tilting vehicles and magnetic traction allow hyperloop to navigate tighter turns and steeper gradients than trains, while magnetic levitation reduces the need for perfectly aligned infrastructure. This allows for easier integration alongside existing transport corridors – in particular along highways.

High safety, resilience, and reliability: The enclosed tube protects from external elements, making hyperloop resilient against weather conditions and other disruptions.

High capacity: Vehicle-based magnetic switching eliminates the fault-prone moving components that typically limit the capacity of conventional rail systems, allowing for a higher frequency of service and greater passenger and cargo throughput.

Lower whole life cost: Hyperloop infrastructure is potentially less expensive than traditional high-speed rail. The lightweight vehicles result in lower dynamic loads on already more compact infrastructure. The system can be efficiently scaled with modular construction, and the relaxed infrastructure requirements further reduce costs. Higher speeds mean fewer vehicles are needed to transport the same number of passengers or cargo. Finally, the low maintenance needs and automated nature of the system lead to reduced operational expenses. This lower Capex and Opex mean that it could offer better economic viability and leverage public and private financing through Public-Private Partnerships.

In summary, the hyperloop offers a solution to many of the challenges of modern transport. It combines high-speed travel with minimal energy consumption, zero emissions, low noise and vibrations, and a compact, low-maintenance, cost-effective infrastructure.

THE IMPACT OF HYPERLOOP

With 90% of European cities connected within three hours, the hyperloop opens new possibilities for social and economic unity. Making cross-border travel more accessible strengthens economic integration, supports a more united and connected continent, and improves the overall quality of life for Europeans.

New commuting patterns are unlocked for long and short distances. By making cities that are currently hours away by car commutable, new opportunities for work, education, healthcare, and leisure are created. Connecting not only the largest cities but also the smaller ones in between—without slowing down traffic on the main line—hyperloop serves as a

release valve for the bursting demand in urban centers, enabling people to live in more affordable areas and helping to stabilize housing prices.

Making public transport more attractive, reducing congestion and freeing up capacity. Hyperloop offers reliable, low travel times for longer distances, synergizing with traditional rail networks by serving as feeders into each other's systems. Combined with rail's medium-distance coverage it creates a more connected multimodal network, drawing passengers away from cars and short-haul flights and reducing congestion. By providing a sustainable alternative to short-distance flights, hyperloop frees up airport capacity for economically vital long-distance travel.

Hyperloop can align with current transport infrastructure projects such as road widening, rail construction, or airport expansion, potentially offering a favorable benefit-to-cost ratio. However, for each project, a thorough assessment must be conducted to evaluate the specific context. In many cases, Hyperloop may reduce the need for other costly expansions, contributing to the overall efficiency of the transport network and, in some scenarios, offsetting its costs through improved capacity and connectivity.

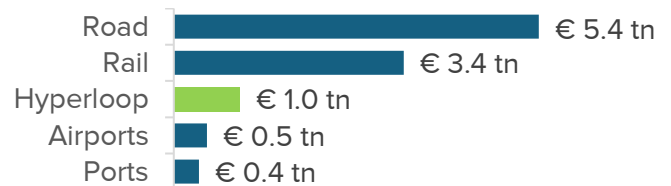


Figure 4 - Required investments into transport infrastructure in 2050 puts hyperloop in perspective (25,000 km of hyperloop)

Hyperloop would evolve logistics and supply chains. Same- or next-day delivery across the entire continent would reduce the need for trucks, warehouses and redundant inventory processes, leading to a decrease in transportation costs and emissions.

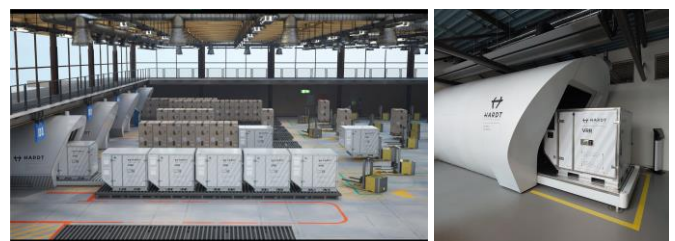


Figure 5 - Rendering of a hyperloop logistics hub (left) and a physical prototype of a docking station (right)

Hyperloop represents a once-in-a-century opportunity to establish a new leading industry focused on the development, planning, and delivery of this innovative transport system. Europe can position the hyperloop as a large-scale export product, creating

high value-add jobs, driving technological innovation, and setting global standards.

The European hyperloop network. The application of hyperloop on a European scale of 25.000 km would lead to an expected modal shift from European aviation to hyperloop of as much as 66%, with annual demand reaching 800 billion passenger-km, including 440 billion passenger-km shifted away from aviation and 220 billion passenger-km shifted away from road transport. The total annual financial and socio-economic benefits of such a modal shift could be over €200 billion, with an annual reduction of 100 million tonnes of CO₂.

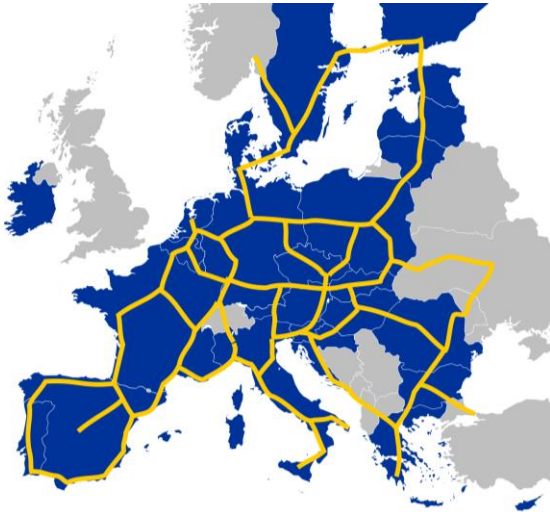


Figure 6 - A potential European hyperloop network

ALIGNMENT OF HYPERLOOP WITH EU AMBITIONS

Hyperloop is well-aligned with Europe's ambitions and is already embedded within European policy frameworks. The EU's trans-European transport network policy (TEN-T) includes hyperloop as a new railway technology. Specifically, hyperloop has the potential to set new benchmarks in three key areas of the TEN-T requirements:

- **Travel Speed:** Current TEN-T policy mandates that passenger railway lines on (extended) core network must support traveling at speeds of 160 km/h. The future policy enabled by hyperloop could enable speeds of 500 km/h.
- **Interoperability:** With the deployment of hyperloop, it is interoperable and digital from day one.
- **Airport Connectivity:** Current TEN-T policy requires that major airports with over 12 million passengers annually be connected by rail to provide a competitive alternative to domestic flights. Hyperloop can expand this connectivity requirement, connecting major airports to provide a competitive alternative to European flights.

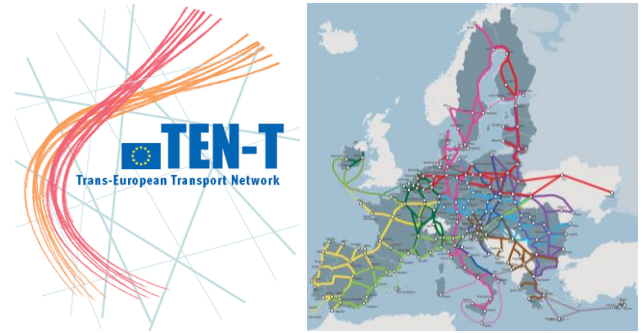


Figure 7 - TEN-T is the European transport planning instrument

The European Commission actively supports hyperloop development through grants and investments from the Europe's Rail Joint Undertaking (ERJU) and the European Innovation Council (EIC) and the European Institute of Innovation & Technology (EIT). ERJU emphasizes exploring non-traditional and emerging flexible and high-speed guided transport systems, like hyperloop, that reduce energy consumption, noise, emissions, and land use. The Hyper4Rail consortium, led by Hyperloop Development Program (HDP), has been granted €2.3 million by ERJU to develop a roadmap towards the industrialization and harmonized implementation of hyperloop technology, and EIC and EIT have provided over €20 million towards the development of the technology.

Hyperloop is recognized as a key part of Europe's future competitiveness. The *Future of European Competitiveness* report by Mario Draghi notes: "transport is set to experience major green and digital transformations, increasingly relying on new technology, including [...] hyperloop trains) to deliver greater speed, efficiency, and cost savings." The report calls for investing as much as €800 billion extra per year in developing such new technologies. The new European Commission has included the promotion of Hyperloop in its work program.



Figure 8 - Mario Draghi presents the future of European competitiveness, including hyperloop as an investment opportunity

INDUSTRY ROADMAP TOWARDS DEPLOYMENT

The hyperloop market is at a turning point, with promising developments. While the largest US company has wound down, China has a 2 km test track with plans for further expansion, India has just finished

their 420 m test track and Türkiye is also working on a test track. Europe is taking a unique approach by bringing various developers together to harmonize the technology and align their efforts.



Figure 9 - Pictures of the test tracks in China and India

Complementary test centers are emerging across the continent, each advancing different aspects of hyperloop technology. The European Hyperloop Center in Groningen, Netherlands, focuses on magnetic lane switching, while the GoTube in Emden, Germany, develops cargo transport solutions. In Munich, the Passenger Hyperloop Demonstrator addresses passenger safety, and the DemoTube in Switzerland explores concrete tube construction techniques. A site in Valencia, Spain, is dedicated to developing linear propulsion systems while a site in Nowa Sarzyna, Poland focuses on levitating on traditional rails.

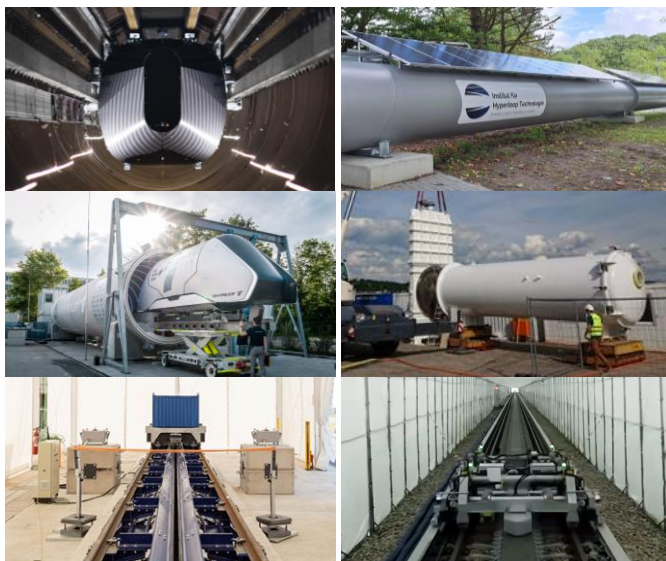


Figure 10 - Pictures of various hyperloop test facilities in Europe

Establishing a European hyperloop industry requires a collaborative effort, much like the early days of Airbus. Currently, numerous partners are involved with various hyperloop developers, contributing expertise and resources. Drawing a parallel to the 1960s, when multiple European companies initially developed competing concepts for a new aircraft, they ultimately came together—with the funding support of several member states—to create Airbus. A similar path could be imagined for hyperloop, where we unite to establish a strong industry capable of delivering the next transformative transport technology.

The development of a unified hyperloop industry in Europe is underway, with the partners of the Hyperloop Development Program harmonizing technology and creating a comprehensive roadmap that identifies remaining technology gaps, outlines the necessary tests and verification processes, and defines key stage gates for development and certification. By building strong industry partnerships, a coordinated approach to the development of a properly defined program is ensured. A financial framework will be developed that allows governments and other investors to co-invest in the industry, rather than in individual players, reducing risk and enhancing the likelihood of success for the entire European hyperloop sector. During this phase, **some public support is needed** to accelerate the development and ensure convergence on the technology.

Building the network follows a phased approach that starts with development and demonstrations, addressing critical gaps, and expanding incrementally.

- **R&D:** Focused on achieving a harmonized system specification and addressing gaps by utilizing existing and proposed hyperloop R&D facilities.
- **Demonstration:** A demonstration track of 3-5 km will showcase safety, efficiency, and functionality as a basis for public confidence and investments.
- **Certification facility:** Extending to 30-50 km for full-speed continuous operations and certification before deployment.
- **Network deployment:** Missing links within the existing transport network are addressed, generating network effects in synergy with other modes. Afterwards, a robust core network is established, finally extending to additional cities and regions to enhance network effects.

CONCLUSION

Hyperloop represents a transformative opportunity for Europe to lead in developing a sustainable, high-speed transport solution that aligns with its ambitions for a greener, more connected, and competitive future. While challenges remain, the ongoing efforts to harmonize standards, build industry partnerships, and develop a comprehensive roadmap demonstrate a clear path forward. By embracing and supporting this development, Europe can position itself at the forefront of this groundbreaking innovation, driving economic growth and enhancing the quality of life for all its citizens.

The Hyperloop Development Program, a European platform of Hyperloop promoters presents this document on behalf of its partners.