ITRL — INTEGRATED TRANSPORT RESEARCH LAB
KTH ROYAL INSTITUTE OF TECHNOLOGY

Acceptance of Cargo Hyperloop in Scandinavia

Advait Mukane
Rohit Shelar
Spoorthi Nagaraj
Xiaoyan Li

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Finally, we recognize that any errors or omissions in this research are entirely our responsibility. While the support and contributions of many have enriched our work, and we have made our earnest efforts to present findings for a genuine purpose, the interpretations, conclusions, and any mistakes remain our own. We are committed to ongoing learning and improvement and welcome constructive feedback to further refine our study.

Team Concept & Scalability,
KTH Hyperloop, Sweden

Executive Summary

This research work explores the acceptance of Cargo Hyperloop technology within Scandinavia, a region noted for its technological advancements and environmental commitment. Amidst growing global emphasis on sustainable and efficient transport, this study provides critical insights into the potential of Cargo Hyperloop as a transformative solution for freight transportation. As the focus of hyperloop enthusiasts shifts from passenger to cargo, it becomes imperative to study how this development and new normal would help this technology progress and turn into a reality.

Acceptance is perceived as a critical juncture marked by a consensus among stakeholders regarding the technology's value and feasibility. It occurs when positive perceptions outweigh concerns, prompting stakeholders to seriously consider adoption. This positive shift not only paves the way for garnering investments from potential stakeholders and investors but also facilitates the realization and commercialization of this transformative technology.

Drawing on comprehensive surveys, expert interviews, and industry perspectives, the research highlights key factors influencing the acceptance of Hyperloop technology. Data reveal significant interest in rapid and sustainable delivery options, with 84.4% of respondents prioritizing environmental impact and 74.6% favoring faster delivery methods like same-day or 1-2 day delivery. While familiarity with Hyperloop is mixed, over half of the respondents possess some awareness, indicating a foundational interest that can be further nurtured through education.

Perceived value and utility along with the sustainable technology aspect of the hyperloop emerges as the major determinant for its imminent acceptance amongst the stakeholders.

Expert interviews reveal both the optimism and skepticism surrounding Cargo Hyperloop. They cite its potential for revolutionary speed, efficiency, and sustainability but express concerns regarding feasibility, integration with existing systems, and economic viability amongst the major stakeholders.

The study concludes that achieving broader acceptance of Cargo Hyperloop requires strategic planning, multi-stakeholder collaboration, and transparent communication. It aligns with the objectives of the EU’s Joint Technical Committee 20 (JTC20), which is developing standards to support Hyperloop's technological and commercial evolution.

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1. Abstract

As the global emphasis on sustainable and efficient transportation intensifies, this study attempts to contribute valuable insights to the broader discourse on the future of transportation with hyperloop technology, particularly for the cargo applications, with a specific focus on the Scandinavian region.

This research work investigates the acceptance of Cargo Hyperloop technology within the Scandinavian context, drawing insights from surveys, expert interviews, and industry perspectives. Through a detailed analysis of demographic data, it reveals a diverse respondent base, with students, working professionals, and businesspeople comprising significant proportions. Geographically, Sweden emerges as a focal point, reflecting its technological advancements and environmental consciousness.

The study highlights sustainability as a paramount concern, with an overwhelming 84.4% of respondents emphasizing its importance in delivery options. Additionally, preferences for faster delivery methods reveal a clear demand for rapid transportation solutions, with 74.6% favoring options such as 1-2 day and same-day delivery. Despite mixed levels of familiarity with Hyperloop technology, over half of the respondents exhibit some awareness, suggesting a foundation for further educational efforts.

Expert interviews provided nuanced perspectives on key determinants of Hyperloop acceptance. While optimism surrounds its potential to revolutionize cargo transportation with its speed, efficiency, and sustainability benefits, concerns about feasibility, integration, and economic viability persist. Strategies proposed by experts emphasize the importance of public awareness campaigns, sustainability promotion, regulatory engagement, and infrastructure integration to address these challenges effectively.

By synthesizing empirical data, expert insights, and industry perspectives, this thesis contributes to a subtle understanding of Cargo Hyperloop acceptance in Scandinavia. It stresses the need for strategic planning, multi-stakeholder collaboration, and transparent communication to navigate the complexities of accepting this transformative transportation technology in the region. The findings offer actionable recommendations for policymakers, industry stakeholders, and researchers to foster broader acceptance and eventual integration of Cargo Hyperloop within the Scandinavian transportation landscape.

2. Introduction

The essential foundation and prerequisite for regional and global supply chains lie in the adaptability, dependability, and robustness of the logistics network (Neu et al., 2023). The functionality of transportation infrastructure, resistant to natural disasters, pandemics, and geopolitical tensions, is crucial for supporting the transportation of goods upon which many societies rely.

Events such as the COVID pandemic highlighted the critical necessity for transportation networks to exhibit a high degree of adaptability, allowing them to promptly respond to evolving requirements. Flexibility in altering cargo volume becomes paramount during such circumstances, emphasizing the importance of transportation systems that can efficiently adjust to dynamic and unpredictable conditions.(Neu et al., 2023)
Post-pandemic, there's a significant surge in trade and retail logistics, undergoing a substantial period of expansion. Precedence Research (Retail Logistics Market Forecast, 2023 - 2032) forecasts that the global retail logistics market is poised for remarkable annual growth of 12.4%, projecting it to surpass $465 billion by 2030.

Hyperloop has been a topic of significant interest and development since Elon Musk introduced the concept in his white paper, "Hyperloop Alpha," published in 2013. The Hyperloop proposes a high-speed transportation system in which pressurized pods travel through low-pressure tubes at speeds exceeding 700 miles per hour. This revolutionary idea aims to drastically reduce travel time between cities, making transportation more efficient and environmentally friendly.

Since the publication of Musk's white paper, numerous efforts have been made to bring the Hyperloop concept closer to reality. Various companies, including Virgin Hyperloop and Hyperloop Transportation Technologies, have been at the forefront of research and development. These companies have conducted extensive testing and have built prototype tracks to demonstrate the feasibility of the technology.

In the recent news (BBC, Feb 2022), Virgin Hyperloop, initially envisioned as a revolutionary passenger train service, has disclosed its shift in focus toward cargo transportation instead. Hyperloop Transportation Technologies, headquartered in Los Angeles with branches in Dubai, is advancing an express freight operation aimed at swift unloading and loading processes, aimed at alleviating congestion at busy shipping terminals (The National News, Dec 2023). This pivotal transition suggests a strategic reevaluation and a recognition of the evolving demands and opportunities within the transportation industry.

Does the Hyperloop for Passengers seem elusive in the near future?

Richard Geddes, professor and founding director of the Cornell Program in Infrastructure Policy at Cornell University, notes that with new technology, accidents are inevitable. While damaged freight is a concern, it fortunately doesn't involve human injuries. Geddes explains that the current focus in the hyperloop space is to first develop operational systems for freight, addressing engineering challenges and ensuring safety. This approach aims to perfect the technology before tackling the complexities of human transport.

Brandom, 2013 discusses some major reasons for Hyperloop to be technically challenging to implement for human transport, namely

Tube Smoothness: Maintaining a smooth interior surface of the tube is crucial due to the minimal gap between the pod and the tube wall. Even a small bump could result in catastrophic damages, necessitating an expensive production process.(James Powell PhD, co-inventor of the maglev train)

Curvature and G-Force: The Hyperloop's high speeds and sharp curves pose a challenge in managing lateral G-forces, potentially causing motion sickness among passengers. Musk's planned route aims to limit lateral G-forces to 0.5 Gs, but this may still lead to discomfort for some passengers.(James Powell)

Technological Feasibility: While the Hyperloop concept utilizes existing technologies like magnetic linear accelerators and air bearings, adapting them for the proposed system presents engineering challenges. Maintaining pressure in the low-pressure tube and ensuring smooth operation are key areas of concern.

Kassebi and Siegfried (2022) too discusses some impediments and possible direction for the hyperloop technology.

Collaborative Efforts for Technological Advancement

The advancement of Hyperloop technology hinges on a synergistic approach involving both corporate entities and public sector initiatives. Increasing the technological readiness levels (TRLs) of Hyperloop systems requires joint actions to address developmental challenges, funding requirements, and regulatory considerations. The integration of diverse expertise and resources from both sectors is crucial in overcoming the current limitations and accelerating progress toward practical implementation.

Nacelle Design and Aerodynamics

The nacelle's design plays a pivotal role in the Hyperloop system’s performance. The frontal size and shape of the nacelle determine the aerodynamic drag it encounters, which directly affects the operating energy consumption. A well-designed nacelle with an optimal blocking ratio—reflecting the proportion of the nacelle that obstructs airflow within the tube—can enhance aerodynamic efficiency. Additionally, refining the material properties and aerodynamic characteristics can help reduce the overall weight of the nacelle, contributing to lower energy demands and improved passenger comfort by minimizing vibrations and pressure changes.

Tube Design Challenges

Despite advancements, Hyperloop tube design remains constrained by several factors. The lack of full-scale test facilities hampers the ability to conduct realistic and comprehensive assessments of tube performance. Additionally, the absence of standardized measurements for tube diameter complicates the design process, as varying diameters can impact aerodynamic drag and system efficiency. Moreover, verifying materials for dimensional stability is essential to ensure the structural integrity of the tubes over time. These challenges highlight the need for ongoing research and development to establish standardized protocols and materials that can meet the stringent requirements of high-speed travel.

Need for System Simulations

To realize the vision of ultra-high-speed travel, system simulations are indispensable. These simulations are critical for designing an aerodynamic gondola that can achieve the projected speeds while accommodating passengers comfortably. They allow researchers to model and test different configurations, assess aerodynamic performance, and optimize design parameters before physical prototypes are constructed. By simulating various scenarios, engineers can refine the gondola's shape, size, and structural features to ensure it meets performance targets and safety standards.

The European Union (EU) witnessed a steady increase in greenhouse gas (GHG) emissions from domestic transport until the disruption caused by the Covid-19 pandemic. (EEA,2023) The report shows that the growth was mainly attributed to the rise in passenger transport and inland freight volumes. During 2019-2020, GHG emissions from transport declined by 13.5% due to the pandemic but rebounded in 2021, experiencing an 8.6% growth. Preliminary estimates for 2022 suggest a continued upward trend with a 2.7% increase.

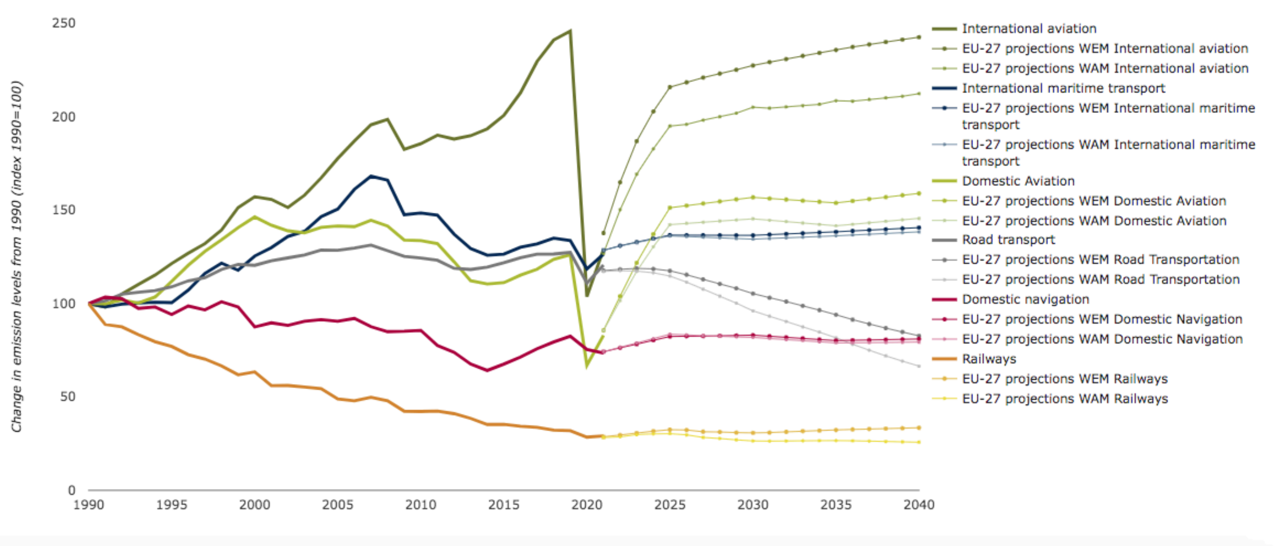


Figure 1. Greenhouse gas emissions from transport in the EU, by transport mode and scenario(source:EEA)

While emissions from non-transport sectors decreased by 15% (1990-2007), transport emissions surged by 33%, constituting 40% of Nordic countries' CO2 emissions.(Langeland et al., 2019/2020)
In 2022, over 50 MtCO_2e of greenhouse gas (GHG) emissions were attributed to the transportation sector, representing the highest share in the Nordic countries(Tiseo, 2023).

Scandinavia is a region in Northern Europe, traditionally comprising Norway, Sweden, and Denmark. This grouping is based on cultural, historical, and linguistic connections rather than formal political boundaries. Scandinavia is characterized by its shared Viking heritage, closely related Germanic languages (Norwegian, Swedish, Danish), and similar social systems.(The Nordic Nomad, n.d.)

There is no official recognition of Scandinavia as a political entity or in international law; its composition is defined by cultural and historical ties. While Finland and Iceland are sometimes included in discussions about the broader "Nordic countries", they are not strictly part of Scandinavia.(The Nordic Nomad, n.d.)

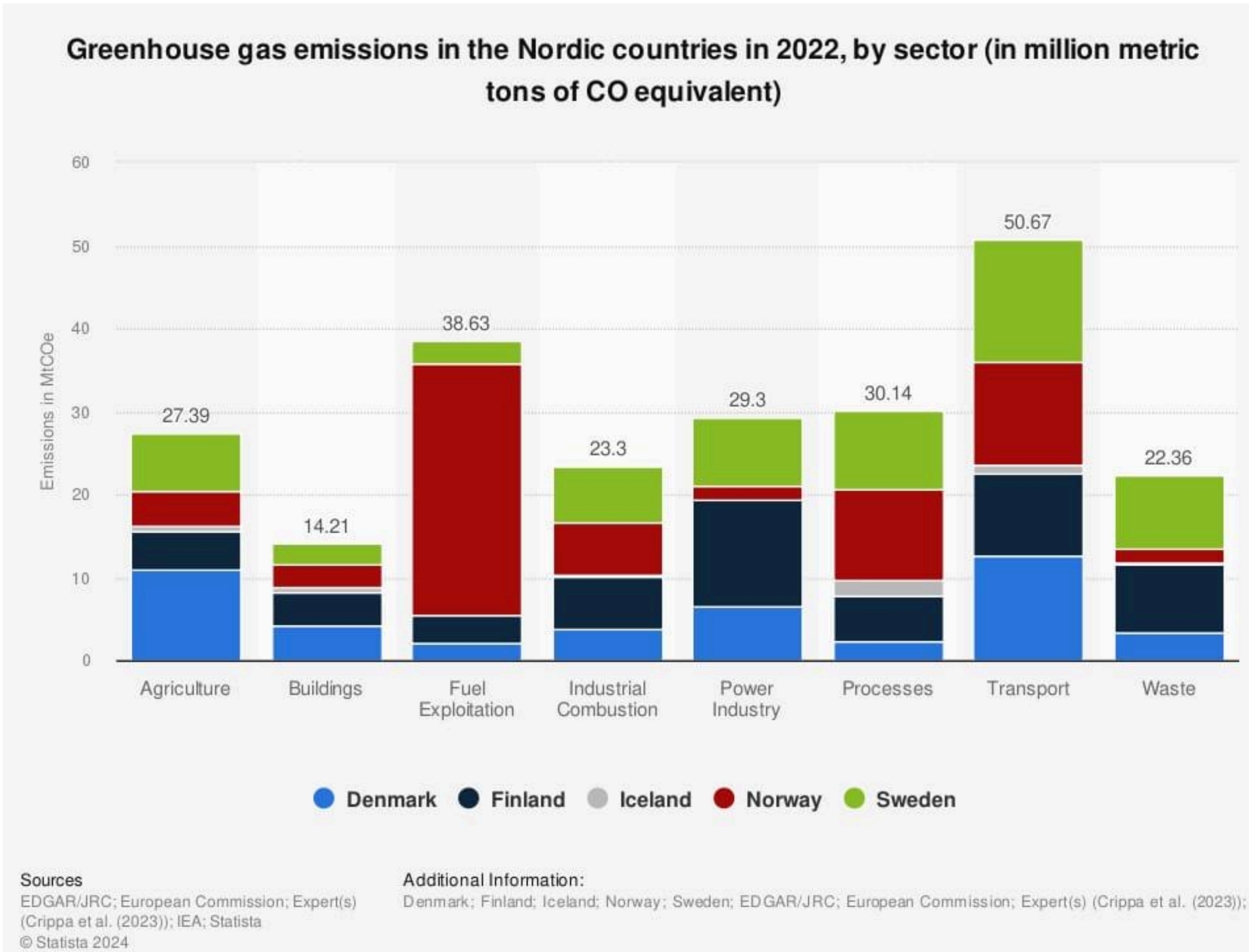


Fig:2 Greenhouse gas emissions in the Nordic countries in 2022, by sector(in million metric tons of CO_2 equivalent), Source: Statista

From the above graph it is deduced that the Transport sector in Scandinavia(Nordic minus Iceland, Finland) is the major contributor of GHG emissions of roughly about 50 MMT of CO2 equivalent.

Achieving carbon neutrality in Nordic freight transport demands substantial use of low-carbon fuels and electricity, and in the near future, on-road freight primarily relies on biofuels, transitioning to electrified options and/or hydrogen in the long term. (Larsson et al., 2019/2020). The successful implementation of these alternatives hinges on robust policy support.

Scandinavian Country & Finland	Summary of main challenge(s)
Denmark	The decline in road transportation emissions remains sluggish, despite policies encouraging the adoption of new electric vehicle registrations. Efforts to decrease emissions from heavy trucks are ongoing.
Finland	Opting to reduce the blending obligation poses challenges. Political hurdles emerge when considering pricing instruments like taxes and road charges to influence demand.
Iceland	Despite efforts in electrification, emissions are on the rise due to heightened transport demand. Challenges include a lack of transparency and foresight in deploying economic instruments. Additionally, there's a deficiency in targets and initiatives for harder-to-mitigate sectors, including heavy-duty vehicles, aviation, and domestic shipping.
Norway	The hurdles encompass topographical, technical, and financial challenges. In deep-sea shipping, there is a deficiency in the development of climate-friendly designs and fuels.
Sweden	Absence of comprehensive political agreements on stable long-term conditions for fuels, including biofuel production in Sweden. Reduced GHG reduction mandates pose challenges. There is a necessity for additional policy measures facilitating swift electrification and enhanced transport efficiency.

Table 1: Adapted from The domestic transport sector across the Nordic countries – summary of main challenges(Nordic Stocktake)

This research endeavors to explore the subtle aspects influencing stakeholders' perspectives on cargo hyperloop technology in Scandinavia. By analyzing the fundamental principles and functionalities of hyperloop systems, the study aims to highlight the importance of aligning hyperloop technology with broader sustainability goals and aims to decipher how different stakeholders, including the general public, policymakers, and key industry players, perceive this innovative mode of cargo transportation. Through this paper, we aim to provide a comprehensive understanding of the acceptance landscape for cargo hyperloop technology in Scandinavia. By addressing key questions, analyzing perceptions, case generation for its application and anticipating future trends, the research aims to contribute to the ongoing discourse on sustainable and transformative transportation solutions in the region and beyond.

3. Research Objectives & Questions

The primary objectives of this research are:

1. To analyse the current awareness levels and understanding of cargo hyperloop technology among the general public, policymakers, and key stakeholders in Scandinavia.

2. To identify the factors influencing societal perceptions, both positive and negative, regarding the integration of cargo hyperloop systems into the existing transportation infrastructure.

3. To explore the role of cultural, economic, and environmental considerations in shaping public attitudes towards the acceptance of cargo hyperloop technology.

4. To assess the impact of informational campaigns, public engagement initiatives, and pilot projects on enhancing public awareness and acceptance of cargo hyperloop in Scandinavia.

5. To investigate the integration challenges and opportunities in existing transportation and logistical frameworks.

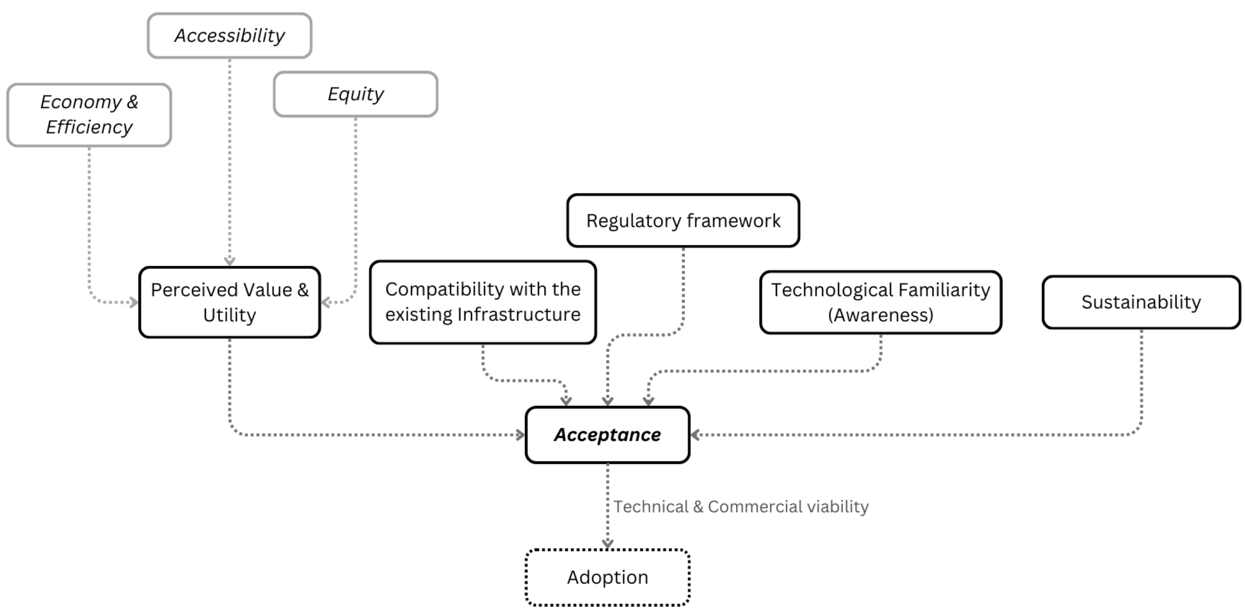


Fig: Conceptual Model

Fig 3: Conceptual Model to study Acceptance of Hyperloop Technology for Cargo Applications

The conceptual model above visualizes the relationship between broader themes as determinants influencing the acceptance of Cargo Hyperloop. Research and analysis also aims to find the degree of contribution of each theme to the convergence point i.e the acceptance.

3.1 Main Research Question

What are the key determinants influencing the acceptance and successful integration of cargo hyperloop technology within the transportation infrastructure of Scandinavia, considering the perspectives of the general public, policymakers, and the key stakeholders ?

3.2 Sub-questions

R1. How do different stakeholders understand and perceive the basic principles and functionalities of hyperloop **systems** and its application in cargo movement?

R2. To what extent have informational campaigns, public engagement initiatives, and pilot projects impacted public **awareness** regarding hyperloop technology in Scandinavia?

R3. How do key stakeholders perceive the feasibility and potential benefits of this **integration**?

R4. What challenges and opportunities exist in integrating cargo hyperloop technology into existing transportation and logistical frameworks in Scandinavia?

4. Methodology

A quantitative survey with seven questions was conducted to address Research Question 2, targeting respondents from Scandinavian countries (Denmark, Norway, and Sweden). The survey was distributed online through various channels to ensure broad reach and response. For the remaining research questions, semi-structured stakeholder interviews were conducted with key industry experts, policymakers, and business leaders. These interviews were recorded, transcribed, and analyzed using thematic analysis to gain in-depth qualitative insights. This mixed-methods approach ensured both quantitative data from a broad audience and qualitative insights from key stakeholders.
Literature review and analysis are integrated to address all research questions wherever applicable, yielding foundational and developmental insights on the subject matter. This not only allows us to explore the breadth of knowledge surrounding the research questions but facilitates a deeper understanding of the subject matter and allows for the identification of key trends, gaps, and areas for further exploration.

Research Question	Literature Review	General Public Survey(G)	Expert Interview(E)
R1	☑	☑	☑
R2	☑	☑	
R3	☑		☑
R4	☑	☑	☑

5. Literature Review

Hyperloop technology is like a futuristic dream: sleek pods zip through tubes at super-fast speeds, powered by solar energy. This concept promises to drastically cut travel times and change how we think about distances (González-González and Nogués, 2017; Arup et al., 2017; Werner et al., 2016). Advanced propulsion systems enable these pods to move as fast as airplanes but with much lower energy and maintenance costs (Arup et al., 2017).

To go even faster and reduce air resistance, Hyperloop includes a clever system that moves air from the front to the back of the pod, making it sleeker and faster (Yang et al., 2017). Computer models suggest that certain pod shapes, like an oval head and a round tail, work best to reduce air resistance (Yang et al., 2017). However, there's a tricky balance to find: the tubes need to be kept at a low pressure to work efficiently but not too low that it uses up too much energy (Decker et al., 2017).

The tubes themselves could be built underground or lifted on tall pillars, which would save space and reduce the impact on the environment (Werner et al., 2016). Safety is a significant priority: each pod will have backup batteries in case of power cuts, emergency brakes, and wheels for extra safety (Taylor et al., 2016; Werner et al., 2016).

Hyperloop, a groundbreaking transportation system, offers rapid, high-volume cargo transport over short and medium distances, complementing existing railway networks. Comprising tubes, pods, and terminals, the Hyperloop system operates within sealed, low-pressure environments. Pods, pressurized to atmospheric levels, glide with minimal air resistance through the tubes, propelled by electrically powered magnetic levitation and guidance systems. Terminals manage pod arrivals and departures, ensuring seamless logistics operations (Motwani and Gupta, 2021).

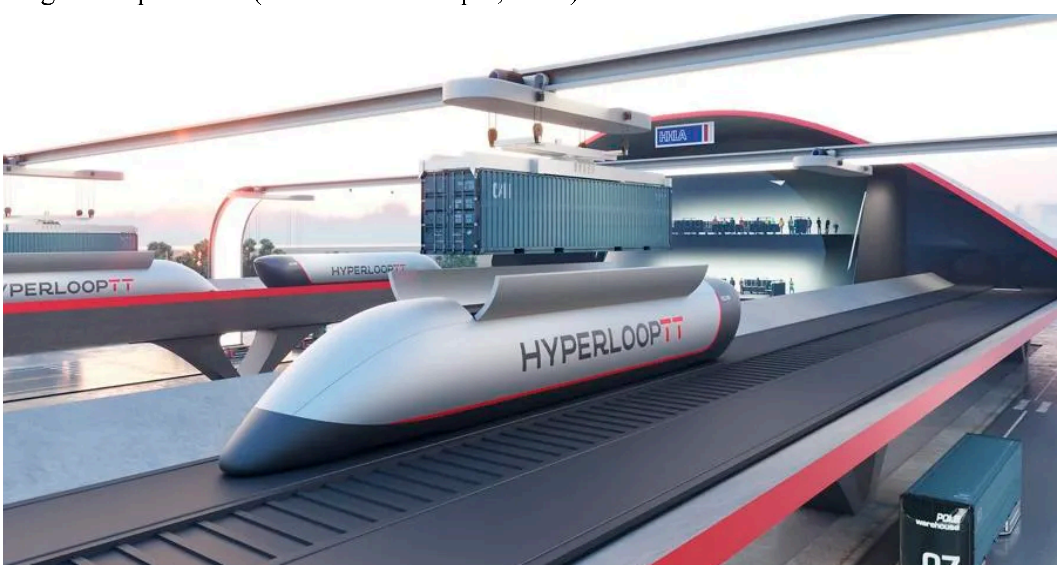


Fig 4: Hyperloop in Cargo Application(Concept); Source:HyperloopTT

CargoTube, an adaptation of the Hyperloop concept, holds promise for significantly reducing the energy demands of transportation and curbing greenhouse gas emissions, surpassing conventional surface or airborne transport methods (Neu et al., 2022). Unlike Hyperloop, CargoTube utilizes more conventional track technologies, akin to trains or streetcars, to navigate and propel vehicles within the tubes. This approach allows for the adoption of large-diameter steel tubes similar to those used in pipeline infrastructure for gas or water. Leveraging existing technology and components enables CargoTube to slash development costs and rapidly expand transportation networks. Ultimately, CargoTube strikes a harmonious balance between performance, efficiency, and lifetime cost, offering an intermodal cargo transport solution tailored for industrial logistics and transportation corridors (Neu et al., 2022).

Despite some safety concerns, like ensuring the tubes are strong enough, Hyperloop could revolutionize how we travel (Arup et al., 2017). But there's still a lot of work to be done to make it a reality. With more research and development, Hyperloop could transform transportation and meet the needs of tomorrow's world.

History of Pneumatic Passenger Transport and Hyperloop Technology

The origins of hyperloop technology can be traced back to the early 19th century with the conception of pneumatic tube mail by Danish engineer George Medhurst in 1810. Medhurst envisioned transporting parcels through iron pipes using compressed air. The first operational system based on this concept began in 1853 at the London Telegraph Office and quickly spread to other cities like Berlin, Paris, and New York. In the U.S., the “Beach Pneumatic Transit” operated under Broadway from 1870 to 1873, transporting up to 400,000 passengers annually. This system, however, was soon replaced by steam-powered and later electric underground railways.(Cargo-Partner, n.d.)

In 1910, rocket pioneer Robert Goddard conceptualized the "Vactrain," a vacuum-sealed tunnel through which passenger capsules would travel at speeds up to 1,600 km/h. Though Goddard’s idea was patented posthumously by his wife, it was far ahead of its time and thus never realized.
The 1960s and 1970s saw renewed interest in pneumatic tube transport. Joseph Foa proposed the “Tubeflight” project, which envisioned trains gliding on air cushions through underground tubes at speeds of 650 to 3200 km/h. Lawrence K. Edwards from Lockheed also developed a concept called the “Gravitrain,” utilizing gravity and vacuum for propulsion. Both projects failed to attract the necessary support and funding.(Cargo-Partner, n.d.)

In the 1980s, Robert M. Salter of the RAND Corporation introduced "Planetran," a concept for electromagnetically powered wagons in pressure-reduced tubes capable of crossing the U.S. in an hour. Around the same time, Rodolphe Nieth designed the "Swissmetro," an underground magnetic levitation train running in a vacuum tunnel. Despite their innovative approaches, both projects were halted due to exorbitant costs. Planetran’s nationwide network was estimated at $1 trillion (equivalent to €3.5 trillion today), while Swissmetro’s cost was around 25 billion Swiss francs (approximately €42 billion today).
The Swissmetro concept indirectly influenced the "Cargo sous terrain" project, aimed at creating an automated underground freight transport system in Switzerland. This project, in partnership with Hyperloop One since 2016, is slated for implementation by 2031, though it will not utilize vacuum or electromagnetic acceleration.(Cargo-Partner, n.d.)

The main advantages highlighted for hyperloop technology (Bronson,2024)

Replacement of Short and Medium-Haul Flights Hyperloop has the potential to completely replace many short and medium-haul flight routes between major European cities. This is advantageous as hyperloop offers the possibility of delivering passengers directly into city centers, unlike airports which are often located far from urban areas. This could have significant impacts on climate change if hyperloop displaces a large proportion of these flights and even surpasses the energy efficiency of trains.

Time Savings and Convenience Hyperloop offers considerable time savings and convenience compared to air travel, particularly in terms of airport logistics. This could lead to a paradigm shift where people are able to live and work much further apart than is currently feasible. As a result, there may be a trend of individuals relocating from expensive mega-cities with strained infrastructure to more moderately sized cities with a lower cost of living.

Bronson (2024), also believes that it is probable that initial operational systems will be utilized for logistical purposes before being validated for human use.

5.1 Freight & Logistics Overview

Freight transportation is a vital component of the global economy, but its contribution to carbon emissions is projected to increase significantly. Research suggests that if current trends persist, freight could become the leading emitter of greenhouse gases by 2050 (Greene S, 2020).

Type of freight transport	Amount of freight moved (billions of tonne-kilometers)	CO2 emissions (millions of tonnes)
Air	303	155
Rail	10,842	170
Road (mainly trucking and urban deliveries)	26,807	2,230
Sea and inland waterways	101,486	657

Table 2: Carbon emissions contributions by different transport modes
Source:International Transport Forum. ITF Transport Outlook 2021. (2021).

To get a better idea, let us try to visualise this current scenario graphically

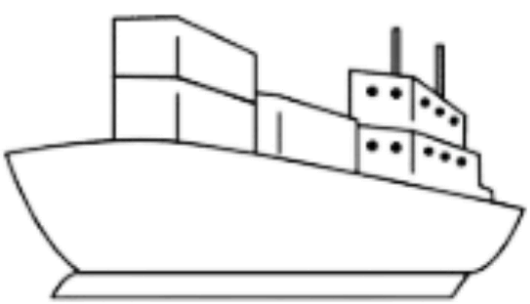
How does our Freight Move?

Freight is measured in tonne-kilometers, indicating the quantity of metric tonnes of cargo transported over a specific distance. In 2020, approximately 140 trillion tonne-kilometers of freight were transported globally.

Air transport moved **303 billion** tonne-kilometers of freight, emitting **155 million tonnes of CO_2**.

Rail transport accounted for **10,842 billion** tonne-kilometers of freight movement, resulting in **170 million tonnes of CO_2 emissions.**

Road transport, primarily trucking and urban deliveries, handled **26,807 billion** tonne-kilometers of freight, contributing to **2,230 million tonnes of CO_2 emissions**.



Sea and inland waterways were responsible for the movement of **101,486 billion** tonne-kilometers of freight, with CO_2 emissions totalling **657 million tonnes**.

**The Size of the green border scales according to the CO_2 emissions.*

Fig 5: Reproduced from the data given in the International Transport Forum, ITF Transport Outlook(2021)

When it comes to carbon-intensity, the following graph gives the overview of the same for different modes of freight transportation

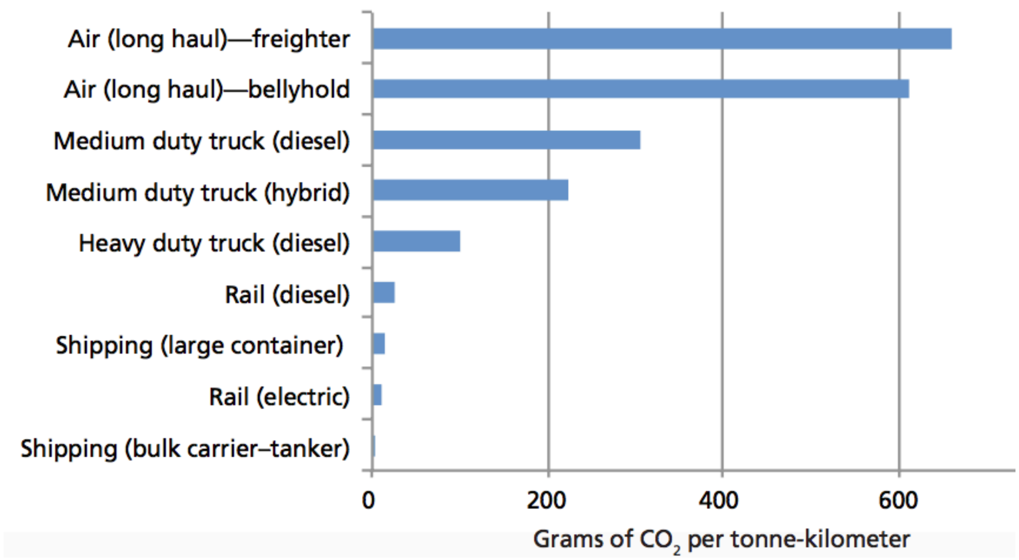


Fig 6 :Average carbon intensity of freight transport modes.
(Source: IPCC, 2014.)

Duin et al.(2023) highlight how the prosperity of the region and its businesses has led to a notable surge in transportation, predominantly by trucks, contributing to heightened levels of traffic, noise, and pollution. They further point out how this increased road transport, exposes manufacturing plants to susceptibility from external factors, presenting significant challenges. They stress how even minor external influences, such as adverse weather conditions or extensive road usage, can have a substantial impact on the efficiency of the manufacturing facility. Consequently, integrating the CargoTube (Hyperloop for cargo transport) as a supplementary component to the on-site logistics hub emerges as a viable solution, providing substantial alleviation for incoming logistics challenges and potentially creating room for the expansion of manufacturing areas.

5.2 Stakeholder Landscape

Stakeholders are increasingly recognizing sustainability as a competitive edge, moving beyond being merely an executive concern. Emerging innovations and markets are already influencing the trajectory of commercial urban transportation. Original Equipment Manufacturer (OEM) technology, electrification, autonomy, sustainable fuels, and digitalization are pivotal aspects shaping the industry's transformation. Furthermore, consumer behavior is evolving, with a growing preference for environmentally-friendly transportation options to fulfill their carbon reduction objectives. (Embracing technology and sustainability in freight transport,2022)

Stakeholder Type	Relevance of Activities
Hyperloop Developers	Develop hyperloop technology according to existing or future standards. Examples include Hardt Hyperloop, HyperloopTT, Nevomo, Swisspod, Transpod, Hyperloop One, Zeleros, etc.
Suppliers/Service Providers	Develop materials, parts, subsystems, infrastructure, and services enabling hyperloop technology in alignment with existing or future standards.
EU/National Legislative Authorities	Public authorities such as Ministries of Transportation, Economic Development, and Innovation, which unlock public funding, develop standards-receptive legislation, and issue standardization mandates.
European Commission (EC)	Introduce funding programs for hyperloop and develop EU regulatory frameworks for hyperloop systems. Mandate European Standardization Organisations (ESOs) for the development of harmonized hyperloop standards.
Standardization Organizations	Provide the standard setting ecosystem by ensuring stakeholder involvement and managing the standardization process (planning, phasing, voting).
National Standardization Organizations (NSOs)	Responsible for developing European consensus and facilitating the participation of national experts/stakeholders in JTC20.
Independent Research Bodies	Define and validate novel hyperloop systems unique to the technology, aid in test planning according to standards.
Certification/Inspection Bodies	Validate testing results, certify interfaces, parts, and processes for commercial use.
Customers/Users	Include infrastructure managers, hyperloop operators, and users/passengers' associations.

Table 3: Stakeholders for Standardisation, JTC20
Source: Adapted from Hyperloop Systems, 2023

The Ministry of Transport identifies itself as a large and visible organization that covers a wide field of tasks, involved in planning, construction, operation, and maintenance as well as regulation and supervision of the entire transport system. It also builds, maintains, and manages the state's property and operates the state's facility management. Simultaneously, society's green agenda drives a technological shift that transforms an entire sector and reduces CO2 emissions. To realize the visions, it has identified strategies that link the connection from the individual task to the realization of our visions, for it is only when we link the content to our everyday life that the visions can really be brought to life. The infrastructure, construction, and regulation it builds and designs today will form the foundation for future generations' green society and green mobility.(The Ministry of Transport, 2024)

5.3 Transport Technology - Development & Diffusion

The adoption of new technologies is often an absorbing phase, where users rarely revert to old technologies once they have adapted to new ones (Hall and Khan, 2003). This tendency contributes to the gradual but steady diffusion of innovations. Another significant aspect involves the uncertain benefits associated with new technologies, which can lead to delays in adoption. Potential users often weigh the option value of waiting until the perceived benefits clearly outweigh the costs (Hall and Khan, 2003). This parallels other investment decisions characterized by uncertain future profits, irreversible sunk costs, and the strategic opportunity to delay action. These factors collectively explain why the diffusion process may proceed slowly.

A critical aspect in the diffusion literature is the role of opinion leaders, who are early adopters regarded as experts and objective evaluators of innovations (Dearing, 2009). However, due to their need to remain impartial, opinion leaders often reject radical innovations. Therefore, suppliers of groundbreaking technologies might find more success targeting innovators instead of opinion leaders during the initial stages of diffusion (Dearing, 2009).

Various factors influence the rate of technology diffusion. Direct benefits, such as increased utility, and indirect factors, such as enjoyment, complementary skills availability, and network effects, significantly impact demand for new technologies (Hall and Khan, 2003). These factors are categorized into three clusters as per Tidd and Bessant (2009): "The Adopter," focusing on individual or organizational characteristics; "The Innovation," concerning the inherent features of the innovation itself; and "The Environment," relating to the contextual factors of the market or environment where the innovation is introduced.

Table 4: General definition of the five characteristics of innovation diffusion theory (Sonnenwald et al., 2001)

Characteristic	Definition
Relative advantage	The degree to which an innovation is perceived as superior to competing products or the products it replaces. This superiority can be in terms of cost, performance, convenience, or other factors.
Compatibility	The extent to which an innovation aligns with existing values, norms, experiences, and needs of potential adopters, as well as how well it integrates with existing technology and standards.
Complexity	The perception of how difficult an innovation is to understand and use. This includes considerations of the innovation's intricacy, technical requirements, and the skills needed for adoption.
Observability	The degree to which the results or benefits of an innovation are visible to others. This visibility can influence the diffusion process by providing social proof and facilitating word-of-mouth communication.
Trialability	The degree to which an innovation can be experimented with on a limited basis. Trialability allows potential adopters to test the innovation's compatibility, observe its benefits, and reduce uncertainty before full adoption.

5.4 Technological Innovation System (TIS) for Hyperloop

The Technological Innovation System (TIS) framework provides a valuable lens to assess the inclusion of Hyperloop technology for cargo transport in Scandinavia. According to the TIS concept, innovation systems comprise actors, institutions, interactions, and infrastructure. Analyzing these elements helps us understand the dynamics of technological change. The TIS approach is instrumental for policymakers to identify systemic issues and formulate strategies for effective technology development and diffusion.

In the context of Scandinavia's transport innovations, including electric vehicles, electric road systems, and biofuels, the TIS analysis focuses on key actors, institutions, interactions, and infrastructure. However, Hyperloop, a transformative technology, is not explicitly mentioned in the excerpt. Considering the TIS perspective, its inclusion can be justified by its potential to revolutionize cargo transport in the region.

Hyperloop's unique features, including high-speed transportation in low-pressure tubes, can address challenges faced by existing technologies. Its introduction would require the identification and engagement of relevant actors, establishment of supportive institutions, creation of interactive networks, and development of necessary infrastructure.

Applying the TIS framework to analyze the inclusion of Hyperloop in Scandinavia's cargo transport can offer insights into systemic elements and functions crucial for successful innovation. Policymakers can use this analysis to navigate challenges, formulate strategies, and foster the integration of Hyperloop within the region's transportation landscape.

Factors contributing to new mobility

Factor	**Description**
Human Behavior	Understanding and influencing human behavior in transportation decisions is crucial for designing effective systems that promote sustainability and safety. This involves aligning policies and services with community and individual needs.
Technology	Technological advancements, spanning from new transportation modes to digital platforms, reshapes mobility. These innovations have the potential to enhance efficiency, reduce costs, and create opportunities across all segments of transportation.
Operations	Efficient operations, encompassing supply chain management, fleet operations, and logistics infrastructure, are essential for maintaining a well-functioning mobility ecosystem. Reliable operations ensure the delivery of seamless mobility services.
Capital	Investment in mobility often requires substantial capital, with new mobility solutions posing unique financial challenges. Unlike traditional forms of transportation, new mobility relies on innovative funding mechanisms such as venture capital to mitigate risks.
Regulation	Regulation and policy frameworks in the mobility sector are critical for ensuring user safety, technical standards, and market fairness. Effective regulation strikes a balance between addressing user needs and fostering innovation within the industry.

Physical Integration	Urban integration aims to create interconnected transportation systems and sustainable urban environments. This involves aligning transportation infrastructure with land use planning to promote seamless connections and well-designed urban spaces.

Table 5: Adapted from Nordic Innovation

5.5 Logistic Demands & Projections

According to the Mordor Intelligence. (n.d.) report, E-commerce has been booming in the Nordics because of COVID-19 restrictions. It highlights that almost nine out of every ten people in the Nordics shop online regularly and the amount of online shopping is expected to keep growing by about 10.17% each year from 2023 to 2027. This rise in online shopping is also increasing the need for delivery services and warehouses. For example, in 2021, the Norwegian postal service, Posten Norge, made $107.2 million in sales, a big jump from the $11.3 million it made in 2020. In Sweden, business-to-business (B2B) and business-to-consumer (B2C) deliveries grew by 17% and 49% respectively in 2021.
The report underlines how the Nordic countries are very early internet adopters and online shopping is very common in the region, which is driving the growth of the wholesale and retail trade end-user segment, which is the largest Segment by End User Industry (32.83 % value share, Wholesale and Retail Trade, 2022)

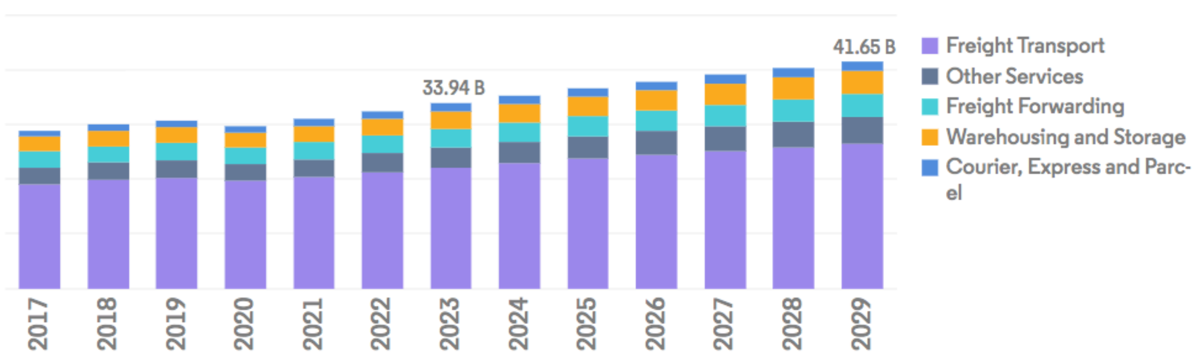


Fig 7: Value of Freight and Logistics Market By logistics function, USD, Nordics, 2017-2029
Source: Mordor Intelligence

Investment and expansion in air freight transportation are staying strong in the region to handle increasing freight volumes. This shows that the region is growing steadily. The air transportation segment is expected to grow the fastest, with an estimated annual growth rate of 3.95% from 2023 to 2029.

In 2022, the largest segment in warehousing, holding 89.69% of the value share, is those with temperature control. E-commerce companies are opting to set up their warehouses in smaller cities near major areas like Stockholm, Gothenburg, and Malmö, where there's high demand.
A.P. Møller – Mærsk, a leading shipping company based in Copenhagen, is set to introduce its own cargo airline in 2023. This initiative aims to significantly increase its air freight volumes, targeting a doubling to 160,000 tons per year by 2040.

The rapid growth of e-commerce is suggestive of some direct and indirect implications for the logistics industry in the near future, and the associated logistical demand seems to provide a fertile ground for the acceptance of Cargo Hyperloop technology in the Nordic region. The region's focus and push for sustainability seems to align well with the environmental benefits of conceived Hyperloop technology, offering a compelling alternative to traditional freight transportation methods, at least to consider and test. Hyperloop's potential to provide rapid, energy-efficient cargo transport aligns with the increasing need for fast and reliable delivery solutions driven by e-commerce growth.

5.5.1 Global demand for freight transport by mode to 2050

The report predicts that the urban freight activity is growing across scenarios, with parcel deliveries expected to experience significant growth. Companies operating in urban areas are expected to anticipate this growth and invest in last-mile delivery solutions to meet the increasing demand for parcel deliveries efficiently.

The following graph attempts to outline the projected future demand for freight, under three scenarios, in billion tonne-kilometers

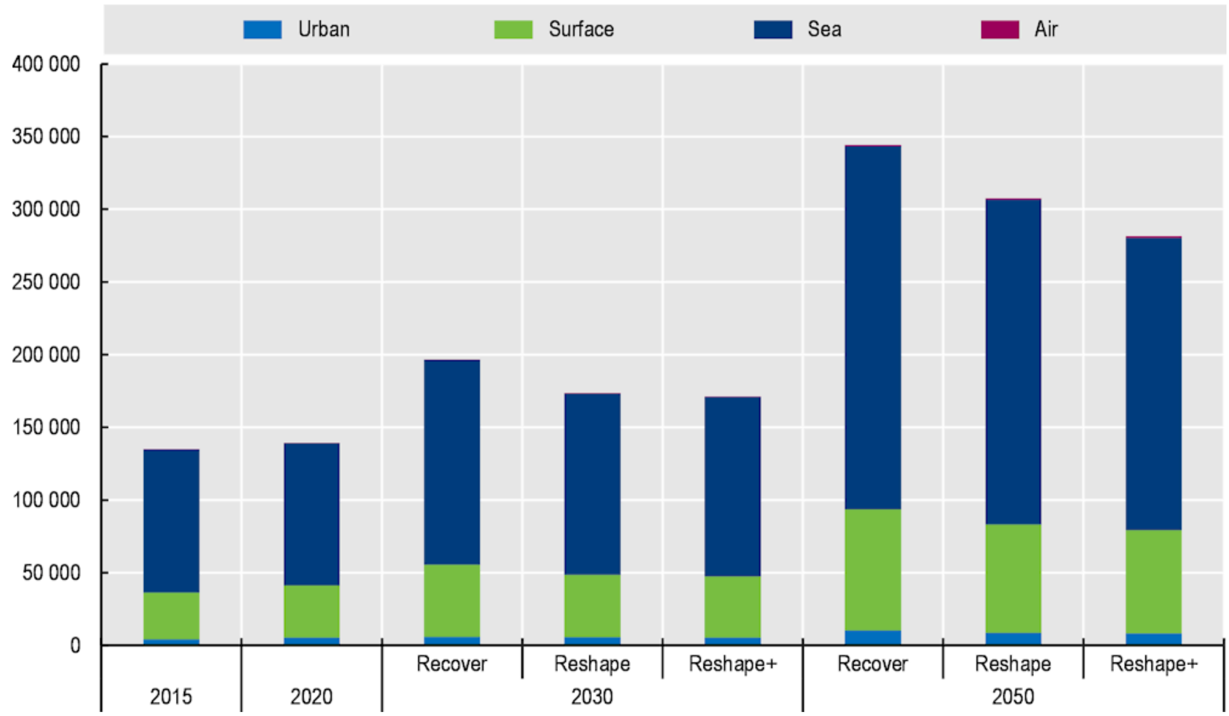


Fig 8: Global demand for freight transport by mode to 2050

Source: ITF Transport Outlook, 2021

However, it is argued that the phenomenon known as reshoring, involving the relocation of manufacturing activities from emerging markets to developed nations, alongside the relocalization of food supply chains and a decline in international fossil fuel trade, has the potential to detach trade growth from global GDP expansion negatively. Additionally, advancements such as miniaturization, digitization, and the widespread adoption of 3-D printing may lead to the dematerialization of certain goods, thereby dampening the demand for freight transport both domestically and internationally. These combined factors could markedly reduce the freight transport intensity of the global economy, although the likelihood of such a scenario remains uncertain.(McKinnon, 2016)

5.5.2 Future Perspective on Network and Operations of Hyperloop

In the future, Hyperloop systems are envisioned to revolutionize both passenger and freight transportation by allowing them to share a unified network. This system offers flexibility in operation, capable of providing point-to-point services akin to aviation or adopting a metro-style approach with multiple stops. Unlike traditional transportation, Hyperloop will utilize a driverless system, enhancing its capability for rapid, frequent travel and accommodating various scheduling models—from fixed timetables to adaptive, demand-responsive services.(Hardt Hyperloop, 2023)

The integration of advanced digital technology will be a cornerstone of Hyperloop's design, setting it apart from conventional modes that often require extensive and costly updates. This digital infrastructure will improve system performance, enabling sophisticated control mechanisms and superior monitoring of environmental conditions and passenger safety. Hyperloop's advanced operational flexibility and integrated digital systems promise to make it a highly efficient and responsive mode of transport, aligning with future demands for adaptable and technologically enhanced mobility solutions.(Hardt Hyperloop, 2023)

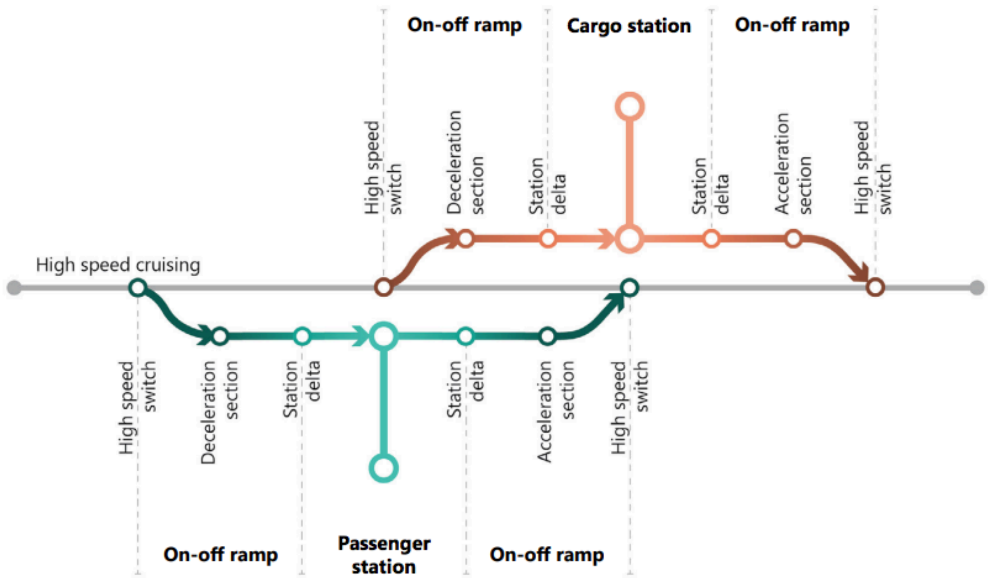


Fig 9:A high-level concept of operations for a point-to-point passenger and cargo service.

5.5.3 Nordic Trade Triangle

The Nordic Trade Triangle represents a cornerstone of the region's robust intermodal transport network, seamlessly linking the capital cities of each Nordic country. Comprising motorways, railway connections, airports, and ports, this interconnected system facilitates efficient movement of goods and people across the region. Notably, the southern node of Sweden serves as a vital gateway, offering swift access to the wider continental European market.(Savills Research, Autumn/Winter 2023)

Within the Nordic Trade Triangle, infrastructure plays a central role in shaping the strategic landscape of the Nordic countries. This importance is underscored by the concentration of over 80% of Sweden's population and businesses within this region. Such a concentration highlights the critical role this infrastructure plays in enabling economic activities, fostering trade, and enhancing regional connectivity. Consequently, investments and developments in this transport network are pivotal for driving economic growth and ensuring the sustained development of the Nordic region as a whole.(Savills Research, Autumn/Winter 2023)

The established intermodal transport system of the Nordic Trade Triangle offers a potential opportunity for introducing cargo Hyperloop in the region. Given its effective connections between capital cities and access to continental Europe, Hyperloop may enhance the speed and efficiency of freight transport.

Through the utilization of existing infrastructure and careful integration of Hyperloop technology, there is a chance that the region could reduce transportation times, decrease logistics costs, and potentially strengthen its position as a logistics hub in Europe.

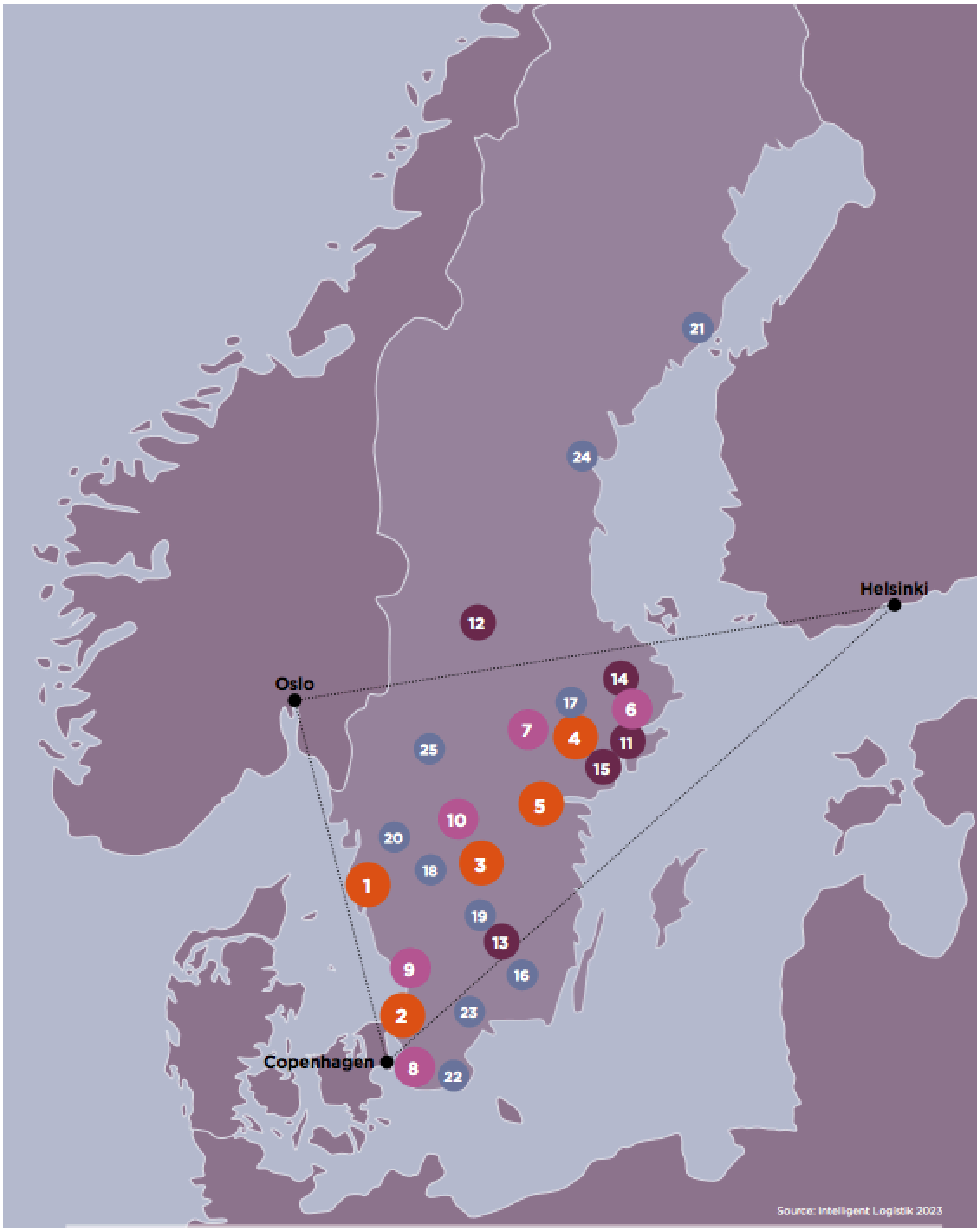


Fig 10: Nordic Trade Triangle with various logistics hubs
Source: Intelligent Logistik 2023 via Savills Research, Autumn/Winter 2023

5.6 Answering research questions R1

How do different stakeholders understand and perceive the basic principles and functionalities of hyperloop systems and its application in cargo movement?

Sweden faces a crucial decision regarding its transportation infrastructure: whether to allocate resources towards high-speed trains or the emerging technology of Hyperloop. Undertaking the construction of high-speed trains without thoroughly exploring and assessing the potential of Hyperloop as a viable alternative would be a missed opportunity, particularly considering the implications for future generations. Thus, it is imperative for Sweden to prioritize the allocation of funds towards comprehensive feasibility studies to thoroughly examine the potential of both options before committing to any large-scale infrastructure projects. This strategic approach ensures that Sweden makes informed decisions that align with its long-term transportation needs and sustainability goals.(Dahlgren, Windh, Hohenthal, & Casselbrant, 2020.)

The hyperloop, an innovative travel method, characterized by its speed and energy efficiency, is experiencing significant advancements globally. This revolutionary mode of transportation, which operates as a magnetic train within a low-pressure tube, is poised to become commercially viable before the year 2030. The development and advancement of this technology are not only being driven by private sector initiatives but are also receiving substantial support from key governmental bodies. In the United States, the Department of Transportation is actively involved, while in the European Union, similar support is being provided. Furthermore, a European standard for hyperloop technology is currently under development, with the Swedish Transport Administration among the contributors. This collaborative effort underscores the urgency for a comprehensive review of the technology's potential and implications for the future of transportation.(Dahlgren, 2021)

In the long-term perspective, the transportation sector is facing a significant challenge. The Organization for Economic Co-operation and Development (OECD) predicts a substantial increase in global transportation demand, expected to rise by about 300 percent from 2015 to 2050. This surge is not only a logistical challenge but also a significant contributor to global greenhouse gas emissions, with the transport industry accounting for approximately 24 percent of these emissions worldwide, and Sweden contributing about 32 percent. To effectively address climate change goals, it's crucial to develop more energy-efficient transportation solutions and these solutions must be considered within a broader context that encompasses the Nordic, European, and global landscape.
Within the European Union, hyperloop technology is recognized as a promising, environmentally friendly solution to future mobility challenges. The EU is actively supporting the development of hyperloop technology through both financial and regulatory measures. A critical question is whether hyperloop can achieve a technological leap at the same or lower investment cost compared to slower alternatives. Implementation studies indicate that the cost per constructed kilometer for hyperloop is comparable to that of high-speed trains. However, the societal benefits of hyperloop are anticipated to be significantly greater, particularly in terms of substantial time savings.(Dahlgren & Myklebust, 2021)

Rising expenses within the supply chain have additionally prompted prospective clients to seek out more cost-effective methods for transporting goods, or preferably, to streamline their operations to minimize the need for spontaneous, costly charters.(Bryant, 2024)

The transportation sector is confronted with a significant hurdle: meeting the rapidly increasing demand for transportation by 2050 while simultaneously adhering to sustainability goals and emission targets set for 2030 and 2050 (Pathways to decarbonise transport by 2050 | ITF Transport Outlook 2021), while the projections suggest that travel demand will double by 2050. To address this challenge, improvements are necessary in energy efficiency, supply chains, capacity, and spatial integration. Failing to meet these demands and sustainability targets could lead to decreased accessibility and connectivity within cities, regions, and countries. Hyperloop presents an opportunity as an innovative transportation mode capable of fulfilling both transportation demand and sustainability objectives, ultimately contributing to climate neutrality and reducing transport emissions by 90% by 2050.(Hyperloop Systems, 2023- CEN's Business Plan for EU)

Carla Bailo, CEO of the Center for Automotive Research in Ann Arbor, Michigan, emphasized that shifting the focus towards transporting goods instead of people would enable the company to expedite the development and implementation of its technology.(Irwin, J, 2022). The same author suggests that prioritizing the use of hyperloop technology for cargo transportation before implementing it for passenger transit has several benefits. She argues that focusing on cargo transportation requires fewer regulatory approvals and simplifies logistical challenges associated with station design compared to passenger transit. It is further highlighted that despite these advantages, the technology faces various obstacles. For instance, the need for straight-line construction poses challenges, particularly in urban areas where buried utilities limit available space. Additionally, scaling up the system would require significant financial investment, potentially costing billions of dollars.

Sebastian Gendron, CEO of Transpod (Parrott, 2017), believes that cargo transportation is one of the primary markets Transpod could penetrate and further highlights the advantage of transporting goods via pods, noting that unlike with passengers, there are fewer constraints, allowing for greater speed and acceleration, with much better efficacy.

The Hyperloop concept is seen as an advanced transportation system featuring pods traversing near-vacuum tubes at speeds up to 1,000 km/h, and it is stated to amalgamate the velocity of airplanes, convenience of trains, and frequency of metros, promising expedited and comfortable long-distance travel. Challenges encompass infrastructure costs, vehicle production, and system optimization for scalability and safety. One of EU funded-project aims to tackle these hurdles by reimagining levitation and propulsion subsystems, potentially reducing costs, streamlining maintenance, ensuring safety, and minimizing energy consumption(TRIMIS, 2019)

5.7 Answering research question R3

How do key stakeholders perceive the feasibility and potential benefits of this integration?

For hyperloop to become a reality, it's essential for Nordic politicians to envision a carbon-neutral alternative to passenger transportation between Nordic urban areas. This vision must also include a commitment to developing a new form of transportation that benefits the Nordic region and, by extension, Europe. The ongoing standardization efforts are laying the groundwork for commercial projects that are projected to be operational by 2030. These projects aim to create a more cohesive and efficient transportation system, moving away from the fragmented approach that currently characterizes the European rail network. This shift towards a unified, hyperloop-based transportation system is a critical step towards achieving sustainable and efficient mobility solutions in the future.(Dahlgren & Myklebust, 2021)

Completely replacing high-emission transportation methods is not realistic. For long-distance and international travel, airplanes are often the most practical option. Switching modes of transportation is challenging because trains can only replace flights on popular routes and for short distances. In freight transport, trucks would still be necessary even if all possible road freight were shifted to trains and waterways. Freight trains are ideal for major freight routes, but trucks offer more flexibility for timely deliveries.(ITF Transport Outlook, 2021)

Take on Equity
It is stipulated that the decarbonisation policies can also help reduce regional disparities in CO2 emissions per capita. However, it is imperative to ensure that efforts to decarbonize transport do not inadvertently exacerbate social inequalities. Vulnerable groups, who have historically been marginalized in transportation planning, must not be further disadvantaged. Therefore, policies aimed at reducing emissions should prioritize equitable access to transportation opportunities for all members of society. This means investing in public transportation infrastructure in underserved communities, promoting affordable and accessible transport options, and ensuring that any additional costs associated with decarbonization efforts are not disproportionately borne by those least able to afford them.By prioritizing social equity alongside environmental sustainability, it is believed that the transition to cleaner transport could benefit everyone, regardless of their socioeconomic status.(ITF Transport Outlook, 2021)

The HYPERNEX project, funded by the EU, emphasizes the importance of regulators comprehending hyperloop operations. Additionally, it is underlined that both industry and the R&D ecosystem require a deeper understanding of how this ultra-fast mode of travel functions. The project aims to act as a catalyst in fostering the development of the European hyperloop ecosystem. It stresses the need to bring together R&D institutions, industry stakeholders, regulators, and societal needs to align with hyperloop developers. By enhancing understanding between hyperloop developers and stakeholders, the project aims to pave the way for the adoption of this innovative mode of transportation.(CORDIS, European Commission, 2020)

Christer Löfving, a strategist within the Swedish Transport Administration, affirms that the Swedish Transport Administration is dedicated to enhancing current transportation infrastructures while remaining abreast of advancements in novel transportation technologies that could complement traditional systems. The administration encourages Swedish industries to engage in the advancement of hyperloop technology while it endeavors to closely track the progress of hyperloop and maglev technologies through its operations, including the exploration of fundamental standardization matters.

Due to significant advancements in electromagnetic traction, levitation systems, and vacuum infrastructure technology, the field has experienced rapid expansion in recent years. Presently, numerous development initiatives are underway globally, with substantial interest observed in Sweden as well.(Elofsson, n.d.)

Regulation is crucial for the realization of Hyperloop technology. The European Commission's inclusion of Hyperloop in its 2023 mobility package is said to be pivotal for regulation. Following a 2020-2021 report assessing regulatory potential, an impact assessment expected by Q3 2023 is set to further this endeavor. Regulatory frameworks are crucial for Hyperloop's commercialization, requiring certification processes. This milestone sets the stage for testing and approving full-scale Hyperloop prototypes, advancing the technology's feasibility(Zeleros Hyperloop, 2022)

The following figure outlines the timeline of development of standards and regulations in EU for hyperloop technology in general

Fig 11: Adapted from Zeleros Hyperloop,2022

5.8 Answering research question R4

What challenges and opportunities exist in integrating cargo hyperloop technology into existing transportation and logistical frameworks in Scandinavia?

Robert Falck (Voices on Infrastructure, 2022), CEO of Einride, admits that the future technologies that hold real value are those capable of mass production and rapid scaling. These must be energy-efficient and designed for large-scale industrial manufacturing. Autonomous technology is perceived to have tangible applications in transportation. Although electrification is progressing, he underlines how it remains considerably more expensive than other technologies. He believes that nearly 90 percent of all transportation could transition to electric and autonomous modes, underpinned solely by the compelling business case, redefining the business model and logic for transportation. This has a potential to profoundly reshape everything from warehouse placement to urban architecture, city layouts, and how the sector engages with the traditional transportation network such as road and rail.

He further emphasizes that at the heart of the matter, identifying a viable business case is essential for sustainability. Without sustainable businesses, sustainability is unattainable. While there are numerous potential cases, the absence of this fundamental understanding prevents change. Additionally, it's crucial to cease subsidizing the outdated system. Although new technologies will revolutionize the world, the current system continues to receive subsidies.

He points out that,
If an advanced transportation technology is to be realized for our pressing needs and demands, it should have a sustainable business model and a profound ecosystem of financing from the stakeholders, incentivised by the public authorities, who must set in to enable this transition by seriously restructuring the subsidies for the incumbent transportation technologies.

Bronson (2024) discusses how the Hyperloop represents a departure from conventional transportation methods owing to a range of technical and systemic differences. Being a socio-technical system, he believes, entails both technical and social challenges and consequences that necessitate careful assessment. From a technical standpoint, according to him, the success of the Hyperloop hinges on several key knowledge domains. These include AI, machine learning, electromobility, materials science, infrastructure development, cybersecurity, and the implementation of smart hardware, and the mastery of these areas is quintessential for achieving the full potential of the Hyperloop concept.

On the social front, it is pointed out that there are numerous considerations spanning policy formulation, urban planning, human-machine interaction (HMI), systems analysis, infrastructure management, and the establishment of sustainable business models. Addressing these social dimensions is crucial for ensuring the seamless integration of Hyperloop technology into existing societal frameworks and maximizing its benefits while mitigating potential risks.

Landscape of typical challenges

Technical Challenges

- Creating a near-vacuum environment within a tube system while ensuring structural integrity to prevent implosive recompression.
- Implementing life-support systems and stability mechanisms within pods to maintain safety at high speeds.
- Developing guidance and control systems for pod movement at high speeds with minimal gaps between them, including contactless methods for track switching.
- Addressing the complexity and cost of maintaining a large vacuum environment and the associated energy requirements.
- Uncertainty regarding the commercial viability of Hyperloop compared to existing maglev train lines, considering potential higher complexity and cost.

Business Challenges

- Balancing development, infrastructure construction, and operational costs against potential revenue streams from ticket sales and station retail to ensure economic viability.
- Need for Hyperloop to not only be viable but highly profitable for rapid scalability.
- Lack of clarity on passenger capacity and willingness to pay for quick travel times, especially in comparison to budget airline industry preferences for cheap ticket pricing over comfort and convenience.

Standardization Challenges

- Requirement for standardization across borders, especially in the European context, to enable economies of scale and facilitate international functionality.
- Necessity for agreed-upon standards for safety, dimensions, and construction to ensure interoperability and efficiency.
- Initiation of standardization efforts by organizations like the Swedish Institute for Standards to address the need for standardized practices within the Hyperloop industry.

Source: Adapted and compiled from 'We need to talk about Hyperloop' ,Bobby Hao Chen & Joshua Bronson,RISE Research Institute,Sweden

Fig 12: Landscape of Typical challenges

The journey towards the digital transportation era won't be swift or without challenges and numerous technological, societal, and legal barriers must be overcome(Tsakalidis, Gkoumas, & Pekár, 2020).
According to the above authors, issues such as standardization for emerging technologies and legal considerations like liability for automated vehicles and drones require careful attention to prevent future setbacks and promote the widespread adoption of technology while ensuring safety and security. To address these challenges effectively, authors believe that it's crucial to implement appropriate governance, regulatory frameworks, and strategies for public procurement. They emphasize how open, real-time data systems play a crucial role in transforming transportation. These digital platforms continuously collect and share information about traffic flow, vehicle locations, and passenger demand. This data allows stakeholders like transportation companies and government agencies to validate new solutions and optimize existing services. By leveraging the right tools and data, authors believe transportation systems can become faster, safer, and more efficient, benefiting everyone regardless of location.(Tsakalidis, Gkoumas, & Pekár, 2020)

However, the authors apprehend that there are challenges and circumstances that extend beyond policy formulation or present difficulties in doing so. Acceptance of technology is influenced by human and economic factors, and is intertwined with contemporary social issues such as safety, security, sustainability, and climate change.

Society, according to them, often exhibits hesitation towards adopting new technologies, particularly during periods of rapid technological advancement, or when there's a risk of creating a digital divide among different demographics. They fear that this deceleration trend could be exacerbated by potential bottlenecks in the design and implementation phases of new technologies and services, which are directly and indirectly influenced by various individual system factors like supply chain disruptions, policy decisions, regulatory maturity, and standardization. It is further highlighted that the proliferation of diverse technologies and standards in the transportation sector, particularly when they serve similar purposes, can hinder the efficient digital transformation of transportation by impeding interoperability and potentially escalating deployment expenses (Tsakalidis, Gkoumas, & Pekár, 2020).

The analysis by Magnusson and Widegren, 2018 identifies several critical barriers to the potential adoption of hyperloop technology in Sweden. These include technological transitions, path dependencies in the existing transport system, and infrastructure lock-in effects. Moreover, limitations in fitting hyperloop within existing technological standards and complexities hinder its adoption. Political factors, including reluctance towards new technologies and lack of appropriate channels for discussion, pose additional challenges. Furthermore, institutional barriers within transport authorities and the absence of research initiatives exacerbate the situation. The combination of technological, market, and institutional constraints suggests significant hurdles for hyperloop introduction in Sweden. Overcoming these barriers will require concerted efforts from policymakers, industry stakeholders, and research institutions to address technological, regulatory, and financial concerns and pave the way for the successful integration of hyperloop into Sweden's transport infrastructure.

However, there is a silver lining in the overall mobility landscape in Scandinavia when it comes to cross-boundary transformational mobility innovations.

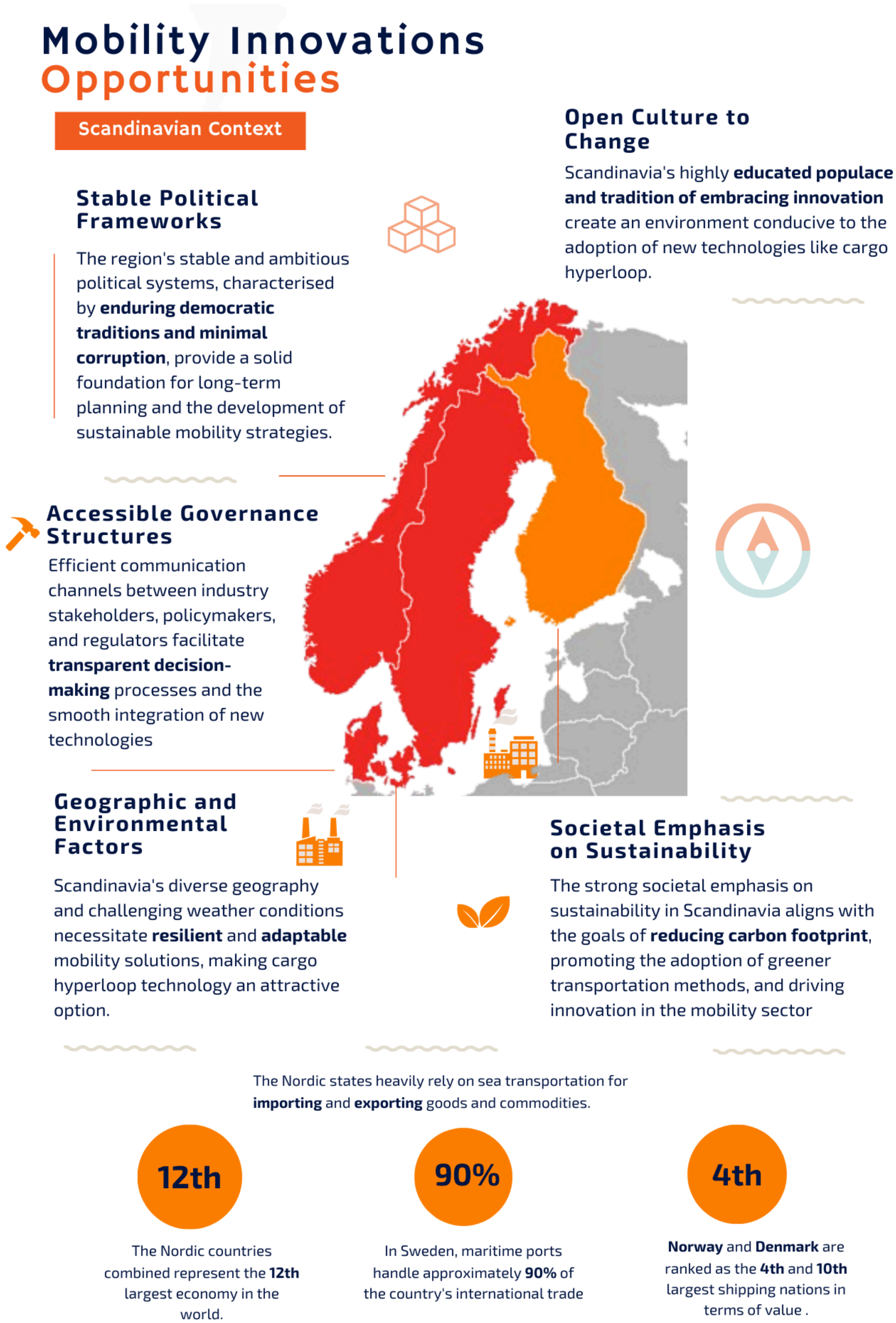


Fig 13: Opportunities in Mobility Innovation(Compiled from Nordic Innovation)

As early as 2011, the European Commission outlined a goal of transitioning up to 30 percent of long-distance road freight, which travels over 300 kilometers, to alternative modes of transportation like rail or water transport by the year 2030. Furthermore, they aimed to escalate this transition, aiming to surpass 50 percent by the year 2050. This strategic move aimed to reduce the environmental impact of freight transportation, particularly by decreasing reliance on road transport for long distances, which contributes significantly to carbon emissions and congestion. By promoting more sustainable modes of transport, the Commission aimed to enhance efficiency and decrease the ecological footprint of freight logistics in Europe.(Chapuis et al., 2022)

5.8.1 Boom of E-commerce: An opportunity for hyperloop in EU?

Fast delivery services, whether they promise same-day or next-day arrival, have emerged as a significant competitive advantage for online retailers, particularly when dealing with products that are either trendy or urgently needed. This heightened demand for rapid delivery isn't exclusive to the consumer market; rather, it extends to the business-to-business (B2B) sector, particularly within the realm of express delivery services that rely on efficient air networks and next-day delivery capabilities.(Hardt Hyperloop)

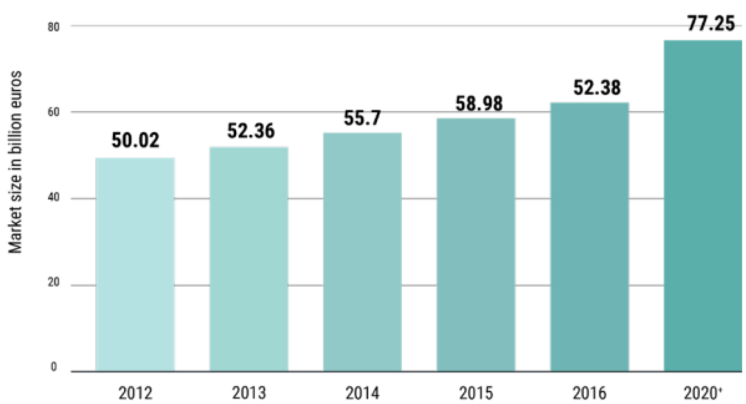


Fig 14: Market size in Europe of the express and small parcels between 2012-2020 in billion euros
Source: Hardt Hyperloop

Within the B2B landscape, there exists a substantial market for items such as spare parts, product samples, cutting-edge technology, and high-value goods. These industries prioritize swift and dependable delivery to ensure seamless operations and customer satisfaction. The reliance on express delivery services underscores the critical importance of logistics in meeting the needs of businesses across various sectors.

One of our interviewees highlighted how the swift logistics network offers a competitive edge to one of the leading automotive giants compared to its other biggest competitor in the region.

The influence of millennials and Generation Z on shopping habits cannot be understated. Millennials, who came of age during economic uncertainty, often prioritize affordability and value when making purchasing decisions. On the other hand, Generation Z, characterized by their digital nativism and concern for social issues, places greater importance on a brand's social responsibility and is less forgiving of any disruptions in service, such as connectivity issues or subpar customer support.

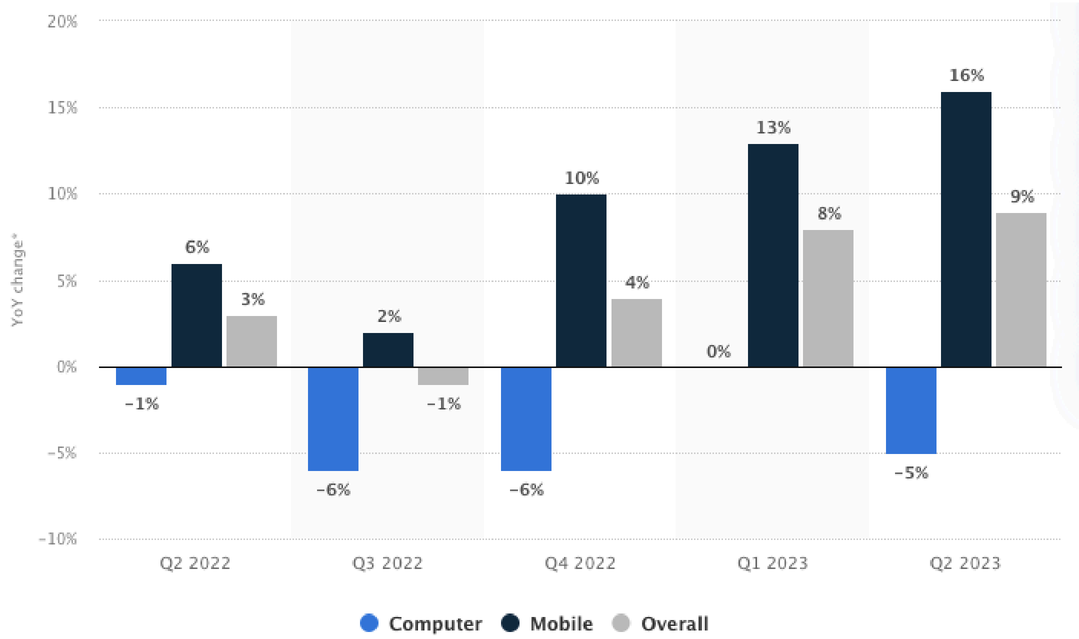


Fig 15: Annual percentage change in digital commerce traffic in Nordic countries from 2nd quarter 2022 to 2nd quarter 2023, by device

Source: Statista

As these younger cohorts transition into key decision-makers within companies, their expectations for service levels are poised to rise even further. This generational shift will inevitably exert pressure on businesses to enhance their logistical capabilities to meet the evolving demands of tomorrow's consumers.

Despite the increasing importance of fast and reliable delivery services, achieving the required level of consistency and efficiency poses a significant challenge for many companies. The existing logistical infrastructure may struggle to keep pace with the escalating expectations of customers, necessitating ongoing innovation and investment in supply chain management to meet the demands of today's dynamic marketplace.

Europe's consumer goods market exhibits significant heterogeneity. Only Northern Europe's e-commerce penetration closely resembles that of the United States, experiencing a Compound Annual Growth Rate (CAGR) of 19 percent from 2019 to 2021. Conversely, Southern and Eastern Europe still have relatively underdeveloped e-commerce sales infrastructure(Cordoba et al., 2022).
Northern Europe for analysis purposes comprises countries such as Finland, Norway, Sweden and UK. The Northern European region, which includes Scandinavian countries, boasts one of the highest shares of value sales in the e-commerce sector.

Fig 16: E-commerce penetration and Growth,
Source: Mckinsey & Company

E-commerce penetration is expected to rise from 15 to 30 percent by 2030 within EU-27 countries.
The following figure shows the progressive increase of e-commerce in the EU-27 countries in the seven different major sectors of consumer goods. This persistent projection of rise in demand along with the demand for quick order fulfillment creates an opportunity space for a transportation mode that is faster, sustainable and reliable in all environmental conditions(flood, snow, storm, rain)

In 2020, the online market across European borders was valued at around 146 billion euros. This marked a significant 35% increase from the previous year. The surge was largely influenced by the COVID-19 pandemic, which accelerated the trend of people shopping online. This growth has been consistent over time, showing that more and more people are buying things from other countries online. It's predicted that this trend will continue to rise, with approximately one out of every four orders being placed from another country.(Ecommerce News, 2021)

The European Commission is working to make it easier for people to buy things online from businesses across the EU. However, right now, it can cost a lot more to have something delivered from another EU country compared to having it sent within your own country. This makes it harder for businesses to sell their products to people in other countries online and many businesses say that expensive delivery and long wait times are big issues that stop them from selling things online to customers in other countries.(European Commission, 2021). Fixing this problem will help e-commerce grow across borders.

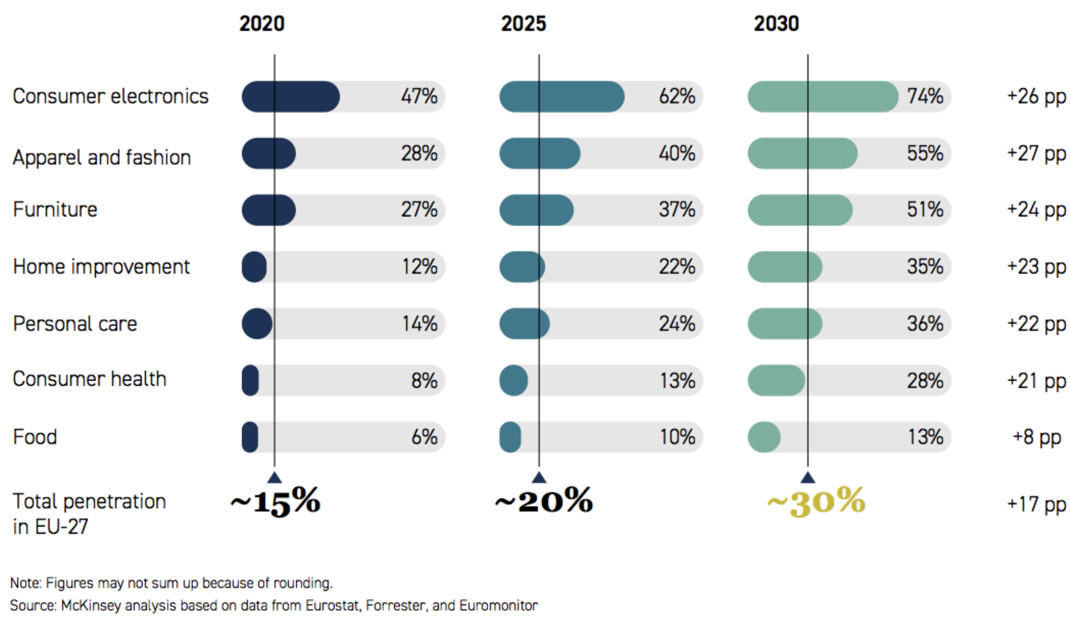


Fig 17: E-commerce penetration across different sectors in EU-27
Source: McKinsey Analysis based on data from Eurostat, Forrester and Euromonitor

Thus, the anticipated doubling of e-commerce penetration in EU-27 countries by 2030, along with the escalating demand for rapid order fulfillment, highlights the imperative for a transportation mode that excels in speed, sustainability, and resilience to adverse weather conditions. The consistent growth of cross-border online shopping, accentuated by the COVID-19 pandemic, reflects a profound shift in consumer behavior, with approximately one in four orders originating from another country. Yet, challenges persist in the form of costly and protracted delivery processes, inhibiting the expansion of cross-border e-commerce. Efforts by the European Commission to streamline cross-border transactions are underway, recognizing the potential economic benefits of facilitating smoother cross-border trade. Addressing logistical barriers and harmonizing regulations can foster a more efficient and cost-effective cross-border e-commerce ecosystem, stimulating economic growth and enhancing consumer access to a broader range of goods and services within the EU.

5.8.2 Solving the Logistics Conundrum: A Gateway to a New Mode of Transportation?

We are presented with a very unique dilemma in terms of policy and decision-making when it comes to logistics transport and infrastructure.

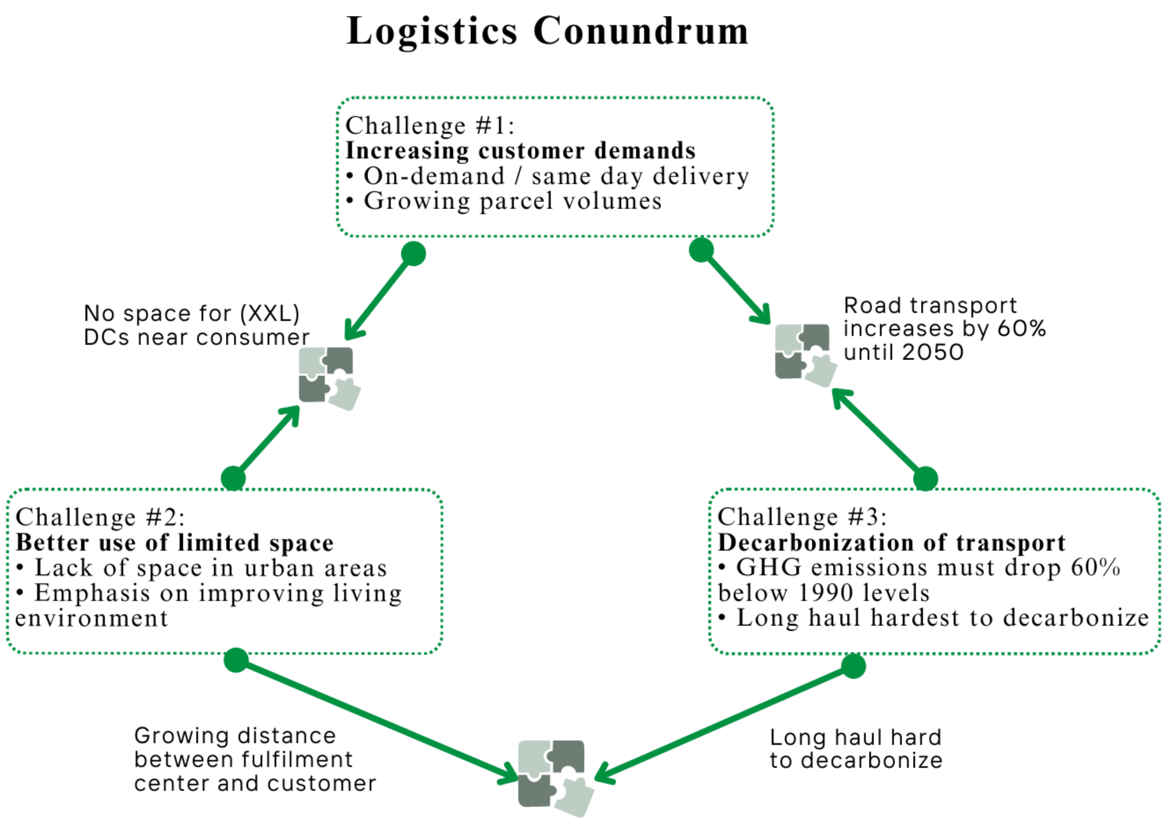


Fig 18: The logistics conundrum amidst rising consumerism
Source: Adapted from Hardt Hyperloop (Caluwe et al., 2021)

The logistics conundrum depicted in the figure above highlights the intertwined challenges faced by the industry, necessitating innovative solutions to balance capacity, speed, and sustainability. Addressing these challenges requires a holistic approach that acknowledges their interconnected nature and seeks integrated solutions.

Challenge 1: ***Increasing Customer Demands***
Customers' expectations for on-demand and same-day delivery, coupled with the surge in parcel volumes, necessitate a reevaluation of delivery networks. Christoph Hempsch from McKinsey & Company emphasizes the critical role of sorting capacity and infrastructure in meeting growing demands. Centralizing delivery sites can optimize routes and enhance efficiency, but it requires strategic investment and operational adjustments.

Challenge 2: ***Better Use of Limited Space***
The scarcity of space in urban areas poses challenges in establishing large distribution centers near consumers. Urban planning priorities further complicate this issue, emphasizing residential and recreational spaces over industrial use. This spatial constraint increases the distance between fulfillment centers and customers, exacerbating delivery challenges.

Challenge 3: ***Decarbonization of Transport***
Stringent targets to reduce greenhouse gas emissions necessitate greener technologies and more efficient transportation methods. However, the need for fast and reliable delivery, especially over long distances, presents a significant hurdle in achieving decarbonization goals.

Interconnections
1. Limited urban space affects the establishment of distribution centers near consumers, impacting delivery efficiency.
2. Increased road transport due to spatial constraints exacerbates emissions, challenging decarbonization efforts.
3. The growing distance between fulfillment centers and customers complicates meeting delivery expectations.
4. Long-haul transportation challenges decarbonization efforts, especially when reliant on extensive road transport.

Hyperloop technology, thus, seems to emerge as a promising solution to future-proof the logistics industry. Its high-speed capabilities can address the need for rapid delivery while minimizing environmental impact. By bypassing traditional road transport limitations and leveraging space-efficient infrastructure, Hyperloop could offer a reliable, demand-resilient mode of transportation. Embracing Hyperloop technology could present an opportunity to break free from the constraints of the current logistics conundrum, paving the way for a sustainable and efficient future in e-commerce and beyond.

Since 1990, long-distance transport, along with data centers, has been one of the few industries unable to cut down on carbon emissions. Even with the Paris Climate Agreement's goal of reducing road transport emissions by 60% by 2050, there's currently no technological fix in place. Short-distance transport has seen progress, with electric trucks emerging as a viable alternative to diesel ones. However, electric long-distance trucking and flying still face significant challenges.(Caluwe et al., 2021)

One innovative solution is Cargoloop, which aims to revolutionize middle or long-haul transport. By using Cargoloop, emissions can be completely eliminated, and travel speed can be boosted by 300% to 800%. This means goods can be transported much faster without contributing to pollution. By saving time in the middle leg of the journey, which could be just a few hours between European cities, the last mile can also be organized more efficiently, ensuring deliveries still meet the same or next-day targets. This approach not only helps tackle emissions but also improves the efficiency of delivery logistics.
(Caluwe et al., 2021)

6. Observations & Discussions

6.1. Survey

6.1.1. Perception

This section summarizes and analyzes the results of a survey conducted to assess the awareness and perception of the Hyperloop technology among different respondents. The survey covered key areas including demographic information, sustainability concerns, delivery preferences, familiarity with Hyperloop technology, and key aspects associated with Hyperloop.

1. **Demographic Information**

The survey captured a diverse group of respondents, including 50% students, 30.3% working professionals, and 19.7% businesspeople. This variety ensures a broad perspective on Hyperloop technology's acceptance, as each group may have different priorities and concerns.

Geographically, the majority of respondents were from Sweden (39.6%), followed by Norway (29.9%) and Denmark (29.6%). Our focus was on Scandinavian countries known for their technological advancements and strong environmental consciousness, making them ideal testbeds for new, sustainable transportation technologies like Hyperloop.

2. **Importance of Sustainability**

A notable 84.4% of respondents considered sustainability either somewhat important (48.4%) or very important (36%) for the delivery of their purchases. This aligns with a growing global emphasis on environmental responsibility. The strong concern for sustainability among respondents suggests that the environmental benefits of Hyperloop, such as its potential for low emissions and energy efficiency, will be a crucial factor in its acceptance. This insight highlights the need for Hyperloop promoters to emphasize its green credentials in marketing and public education campaigns.

3. **Preferred Delivery Options**

When asked about their preferred delivery options, a significant portion of respondents favored faster delivery methods, with 38.9% preferring 1 or 2-day delivery and 35.7% preferring same-day delivery. Only 14% were content with regular 9-10 day delivery, and 11.5% indicated that delivery speed does not matter to them. These preferences underline a clear demand for rapid transportation solutions. Hyperloop's ability to significantly reduce transit times could make it a highly attractive option for time-sensitive deliveries, positioning it well against traditional delivery methods.

However, one of our experts in the interview cautioned regarding this trend. The expert questioned the sustainability of the current consumer demand for quick deliveries in e-commerce. He suggests creating awareness among consumers about the environmental impact of rapid delivery expectations. He believes there should be a discussion revolving around whether there's a need to communicate this message and who should take responsibility for conveying it effectively.

4. **Familiarity with Hyperloop Technology**
The survey revealed a mixed level of awareness about Hyperloop technology. While 44.3% of respondents were not aware of Hyperloop, 44.6% knew a little about it, and 11.1% claimed to know the technology well and followed its progress. This indicates a significant opportunity for increasing public education and awareness. The fact that over half of the respondents had some level of familiarity suggests a foundation upon which further promotional and educational efforts can be built.

5. **Sources of Information about Hyperloop Technology**
Respondents primarily learned about Hyperloop through university/team events (43.9%), science and technology news (24.2%), and social media/peer networks (20.1%). These sources indicate the importance of academic and media engagement in raising awareness about Hyperloop. Effective outreach through these channels can enhance public understanding and support for Hyperloop projects.

6. **Key Aspects Associated with Hyperloop Technology**
Respondents associated Hyperloop with several key aspects:

6.1 Technological Advancements
Technological advancements are a major attraction for Hyperloop technology. With high-speed networks (36.4%), potential future of transportation (35%), and overall technological advancement (30.6%) being highly recognized, these aspects underline Hyperloop's promise of revolutionizing the transportation sector. The high-speed capability is particularly attractive for stakeholders looking for efficient and rapid transit options, making Hyperloop a desirable future transportation method.

6.2 Operational Efficiency
Operational efficiency is another critical factor that supports the acceptance of Hyperloop. Efficient and rapid commuting (36.9%) and being a better alternative to high-speed rail (22%) reflect the expectations of improved travel and delivery times. These aspects highlight the practical benefits Hyperloop can offer in terms of reducing transit durations and potentially enhancing economic productivity through faster logistics.

6.3 Environmental and Sustainability Concerns
The concern for environmental friendliness (22.9%) aligns with the broader societal push towards sustainability. As Hyperloop technology promises reduced carbon emissions and lower energy consumption, it appeals to the environmentally conscious segment of the population. Promoting these benefits can enhance Hyperloop's acceptance among stakeholders who prioritize sustainability.

6.4 Feasibility and Implementation Concerns
Despite the positive aspects, feasibility and implementation concerns remain significant barriers. Scientific feasibility concerns (29.6%), safety and reliability concerns (27.1%), and cost-effectiveness (8.9%) reflect the skepticism about the real-world application of Hyperloop technology. These concerns must be addressed through transparent communication, rigorous testing, and demonstrations of successful pilot projects to build confidence among stakeholders.

Category	Key Aspects	Percentage
Technological Advancements	High-speed Network, Future of Transportation, Technological Advancement	36.4%, 35%, 30.6%
Operational Efficiency	Efficient and Rapid Commuting, Better Alternative to High-speed Rail	36.9%, 22%
Environmental and Sustainability Concerns	Environmental Friendliness	22.9%
Feasibility and Implementation Concerns	Scientific Feasibility, Safety and Reliability, Cost-effectiveness	29.6%, 27.1%, 8.9%

Table 6: Summary of Hyperloop aspects

These associations reflect both the perceived benefits and concerns surrounding Hyperloop technology. The high frequency of mentions of speed, efficiency, and technological advancement highlights these could be the major selling points. However, concerns about scientific feasibility, safety, reliability, and cost-effectiveness must be addressed to foster broader acceptance. This necessitates transparent communication, rigorous testing, and demonstrating the practical benefits and safety of Hyperloop systems as indicated by some experts.

Aggregate analysis of survey at Glance

Key Finding	Discussion
Demographic Distribution	Diverse group including students, professionals, and businesspeople
Geographic Distribution	Predominantly from Sweden, Norway, and Denmark(Scandinavia)
Importance of Sustainability	84.4% consider sustainability important
Preferred Delivery Options	74.6% prefer faster delivery options (1-2 days, same-day)
Familiarity with Hyperloop Technology	55.7% have some familiarity
Sources of Information	University events, science/technology news, social media
Key Aspects Associated with Hyperloop	Speed, efficiency, technological advancement, feasibility concerns, safety, cost-effectiveness

Table 7: Aggregate analysis-Summary

The survey results suggest a generally receptive audience for Hyperloop technology, especially among those who prioritize sustainability and faster delivery options. The demographic diversity and geographic focus indicate potential strongholds for Hyperloop adoption in Scandinavian countries. The high importance placed on sustainability aligns well with Hyperloop's environmental benefits, which should be a focal point in promotional efforts.

However, the mixed levels of familiarity with Hyperloop and the concerns about feasibility, safety, and cost-effectiveness highlight the need for ongoing public education and transparent communication. By addressing these concerns and effectively leveraging academic and media channels, Hyperloop proponents can build stronger public support and drive broader acceptance of this innovative transportation solution.

6.1.2. Acceptance

The allocation of scores across the determinants offers valuable insights into the perceived acceptance of Cargo Hyperloop among stakeholders. Let's delve deeper into the implications of these scores

Perceived Value & Utility

Scores allocated to this determinant suggest stakeholders' perception of the tangible benefits and utility offered by Cargo Hyperloop. Higher scores, such as 55 and 60, indicate that a substantial portion of stakeholders recognize the transformative potential of the technology. This perception is likely influenced by factors such as the system's ability to significantly reduce transportation costs, enhance efficiency, and provide a competitive edge in logistics and supply chain operations.

From the Perceived Value & Utility, responses were also sought for its three major manifestations

Economy & Efficiency This dimension has the highest perceived value overall, with respondents 2, 3, and 5 giving it particularly high ratings (30, 35, and 40 respectively). It indicates that experts see significant economic and efficiency benefits in Hyperloop technology.

Accessibility The ratings for accessibility are relatively consistent, ranging from 10 to 15 across the respondents. This suggests that while accessibility is valued, it may not be perceived as highly impactful as economic efficiency.

Equity The perceived value of equity varies more broadly, with ratings from 5 to 15. Respondent 6 rates equity the highest (15), indicating a recognition of the importance of equitable access and benefits from the Hyperloop system.

Compatibility with Existing Infrastructure

The scores here reflect the extent to which Cargo Hyperloop integrates with and complements the current transportation landscape. Scores ranging from 10 to 25 signify varying degrees of compatibility, with higher scores suggesting better alignment with existing infrastructure and potentially lower resistance from stakeholders. However, it's essential to further analyze the specific areas where compatibility is strong or lacking to address potential implementation challenges effectively.

Regulatory Framework

Scores allocated to the regulatory framework indicate stakeholders' confidence in the legal and regulatory environment necessary for Cargo Hyperloop deployment.
A supportive regulatory framework is crucial for obtaining permits, ensuring safety standards, and resolving legal ambiguities. Scores ranging from 5 to 15 highlight the mixed perceptions regarding the regulatory landscape's readiness to accommodate innovative transportation technologies. Stakeholders may perceive regulatory hurdles as potential barriers to adoption, necessitating proactive engagement with policymakers to address concerns and streamline the regulatory process.

Technological Familiarity

The scores for technological familiarity reflect stakeholders' level of comfort and understanding of the underlying technology powering Cargo Hyperloop. Scores between 2 and 10 suggest varying degrees of familiarity, with higher scores indicating greater confidence in the technology's reliability and feasibility. Stakeholders with a deeper understanding of the technology may exhibit higher acceptance levels, recognizing its potential to revolutionize cargo transportation through advanced engineering principles and proven operational models.

Sustainability

Scores for sustainability highlight stakeholders' consideration of environmental impacts associated with Cargo Hyperloop implementation. With scores ranging from 10 to 28, stakeholders are increasingly prioritizing sustainability criteria when evaluating new transportation solutions.
Cargo Hyperloop's potential to reduce carbon emissions, alleviate traffic congestion, and minimize energy consumption resonates with stakeholders concerned about environmental stewardship and long-term sustainability. Higher scores reflect a growing consensus on the importance of adopting eco-friendly transportation alternatives to mitigate climate change and address pressing environmental challenges.

Final Acceptance Model

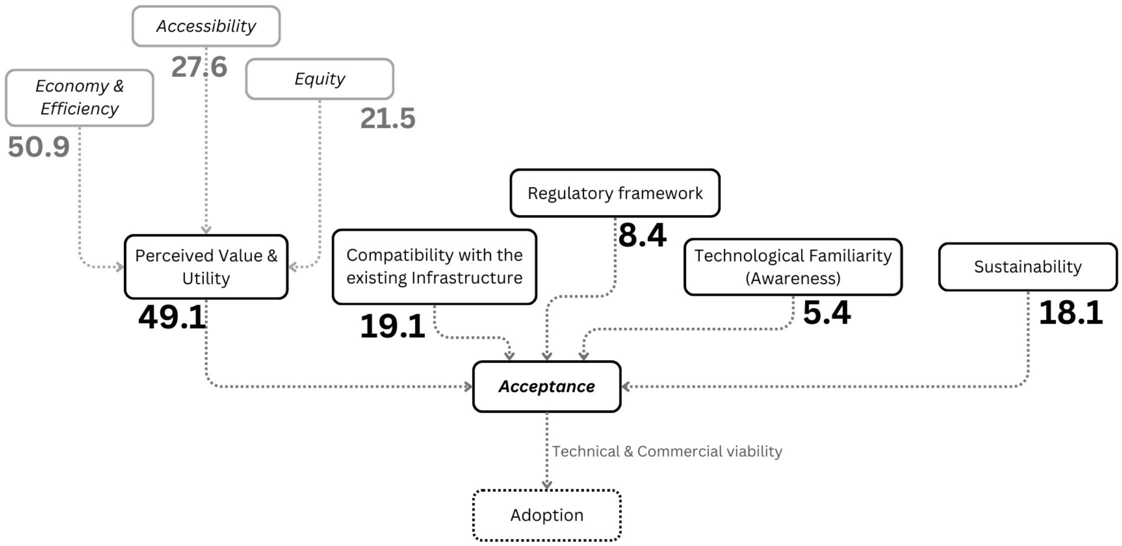


Fig 19: Final Acceptance model

Based on the assessment of the acceptance of Cargo Hyperloop among stakeholders, five critical determinants were analyzed: Perceived Value & Utility, Compatibility with Existing Infrastructure, Regulatory Framework, Technological Familiarity, and Sustainability.

Perceived Value & Utility emerged as the most influential determinant, scoring an average of 49.1 points. Stakeholders prioritize the benefits such as speed, efficiency, and cost-effectiveness. Within this category, Economy & Efficiency received the highest emphasis, indicating the need for cost-effective and resource-efficient solutions. Accessibility and Equity were also considered but were slightly less critical, highlighting skepticism as well as lack of firm knowledge with regards to the importance of broad accessibility and fair distribution of benefits.

Compatibility with Existing Infrastructure followed, with an average score of 19.1, highlighting concerns about the seamless integration of Cargo Hyperloop with current systems, a key factor for minimizing resistance and facilitating acceptance, and thereby adoption.
The Regulatory Framework, with a score of 8.4, indicates that while supportive regulations are essential, they are perceived as less critical than perceived value and infrastructure compatibility, especially in the Scandinavian context.

Technological Familiarity scored 5.4, reflecting that stakeholders are generally comfortable with the technology but do not view it as a primary determinant.

Sustainability, scoring 18.1, reflects the importance of environmental considerations in today's transportation solutions, aligning with growing environmental awareness as well as regulations, and the urgent need to reduce emissions, mandated by future concerns as well as regulations.

6.2 Expert Interviews

6.2.1 Analysis and Discussion

A PhD researcher, who is researching the transition from diesel to electric trucks., focusing on system dynamics, analyzing the interactions and feedback loops within the freight transportation system, and the broader impacts of electrification on the logistics and road freight transport sector; emphasizes the need for a holistic view of system transitions, including infrastructure and stakeholder considerations. Drawing parallels with the adoption of electric trucks, she notes that business-to-business (B2B) acceptance often hinges on cost-benefit analysis and infrastructure readiness. She highlights sustainability goals and regulatory requirements as significant drivers in adopting new technologies, especially in the European context. Companies must meet stringent emission goals, making sustainable transport solutions like Hyperloop more attractive.

"This is exactly this multi-stakeholder thing. You should think about all parts of the puzzle and then exactly regularity is one important part."

She agrees that technological awareness and familiarity are essential for acceptance, and early adoption often involves demonstrating the technology's benefits and reliability in cargo applications before expanding to passenger transport. She stresses the importance of a dynamic model that considers interconnected variables rather than a linear approach. Early-stage engagement with regulators and stakeholders is crucial to navigate potential legal and operational challenges while Multi-stakeholder analysis can provide a comprehensive view of the technology's impact and facilitate confidence building.

An expert from Denmark, consultant by profession, involved in promotion of hyperloop technology in Denmark, provided valuable insights into various aspects of Hyperloop technology and its potential impact on cargo transportation. In Denmark, according to the perception of the expert, public awareness of Hyperloop technology is deemed to be minimal. The perception is often skeptical, viewing it as a futuristic dream rather than a feasible solution.

"The general advantages with Hyperloop are many, but certainly that it's a sustainable, probably close to zero emission transport mode."

While implementing Hyperloop technology for freight, regulatory challenges are perceived to be less significant compared to other sectors according to him. However, the technology's novelty and lack of proven track record pose initial hurdles. While the transition to sustainable transport is crucial for addressing environmental challenges, he believes that Hyperloop is seen as a promising solution due to its potential for low or zero emissions, offering advantages over traditional transport modes.

"From the perspective of Hyperloop, the opportunity it brings is extremely competitive... if you look into same-day delivery opportunities, it is only possible with air freight, which is challenging due to the number of flights and scheduled departures."

However, integrating Hyperloop with existing transport systems presents challenges, particularly regarding intermodal connectivity. However, examples from other countries, such as the Netherlands, demonstrate the potential for seamless integration. Private players may view Hyperloop technology favorably due to its potential to provide a competitive advantage, particularly in terms of speed, capacity, and efficiency. However, skepticism persists until the technology is proven and demonstrated on a larger scale. It is further suggested that logistical efficiencies are a key differentiator in the market. Businesses should recognize the importance of rapid and reliable service logistics, especially in sectors where downtime has significant economic impacts. The ability to provide same-day delivery of spare parts or services can be a decisive factor in customer preference and market competitiveness. He shares how Scania's extensive local service network and immediate parts availability provide a clear competitive advantage over Volvo's centralized logistics, highlighting the critical role of efficient logistics in maintaining market leadership.

"Scania has a big market share in Denmark simply because they can provide same-day repair service due to local garages and spare parts. This gives them a competitive advantage compared to Volvo, which has a 24-hour spare part delivery system."

A leader from Green Safe Logistics expressed doubts about the immediate viability of Hyperloop in Scandinavia, citing the high costs as a significant barrier. However, he sees potential for Hyperloop in Europe, particularly for long-distance routes connecting major cities.

"Hyperloop is the right way to move cargo and passengers in a fast way... We need to act now. We can't wait. We have to start building prototypes."

With respect to Integration with Existing Infrastructure, he proposes integrating Hyperloop with existing railway networks, envisioning a hub-based system where Hyperloop stops at various hubs, connecting with traditional rail for last-mile delivery. The expert sees potential for Hyperloop to revolutionize cargo transportation, especially for fast-moving goods. They envision rapid delivery times, such as delivering fresh produce from Spain to northern Europe within a day.

"There will be a lot of cargo to go into the Hyperloop system... The system will be operating 24 hours a day, 365 days a year."

He suggests a hybrid approach, combining Hyperloop with other transportation modes for optimal efficiency and coverage. The expert doesn't foresee significant regulatory hurdles but emphasizes the importance of cooperation between public and private sectors. But he emphasizes that the margins in the logistics industry are small and act as a deterrent to private investment. He also believes Hyperloop technology is scalable and could integrate well with existing high-speed train networks, providing faster travel options for passengers. At the same time, he acknowledges challenges in promoting new technologies in the transportation sector, citing financial considerations and the need for widespread stakeholder buy-in.

The chairman of Hyperloop Sweden highlights various challenges in promoting Hyperloop technology in Scandinavia. These include funding issues, political priorities favoring other transportation modes, and low stakeholder awareness. There's a need for more research to influence decision-makers positively. Despite efforts such as meetings with politicians, industrial companies, and events like Almedalen political week, the general knowledge about Hyperloop technology among stakeholders in Scandinavia is relatively low. Politicians are hesitant due to perceived uncertainties and short-term focus. Funding challenges are significant, with skepticism about the cost of implementation and doubts about the financial viability of Hyperloop projects. There's a need for studies on capital and operational expenditures to ensure profitability. Integrating Hyperloop infrastructure into urban landscapes poses logistical challenges, such as finding suitable locations for stations. Existing infrastructure priorities, like train systems, may overshadow Hyperloop considerations. While there's interest in both passenger and cargo transportation, he emphasizes that the focus should be on a balanced ratio between the two for financial sustainability. Solely focusing on cargo may not be financially viable according to him, referring to some viability studies. Sustainability, particularly environmental impact, is crucial for Hyperloop adoption. Despite the energy efficiency of Hyperloop, there are concerns about initial CO2 emissions from infrastructure development and Government initiatives and EU laws aim to push companies towards sustainability. Efforts like the JTC20 committee established by the European Commission aim to standardize Hyperloop technology, facilitating its adoption by industry stakeholders. However, regulatory processes may be delayed, he cautions, impacting technology implementation timelines. He stresses the importance of research on economic aspects, environmental impacts, and sustainability of Hyperloop technology. They highlight the need for scientifically supported reports specific to the Scandinavian market to influence decision-makers positively.

"But the interest to start this whole process is very low, and for politicians, who often focus on the next mandate period and elections, it is very tricky to promote."

While the expert in the logistics domain emphasized the critical importance of sustainability in business models for logistics businesses. Sustainability has shifted from being a "nice to have" to a "need to have" in logistics and supply chain operations, driven primarily by the original equipment manufacturers (OEMs) who are pressured to reduce their environmental footprint. He pointed out that the most effective way to mitigate emissions is to avoid transportation altogether. However, for unavoidable transportation, the focus must be on achieving fossil-free operations and minimizing the environmental impact of logistics activities.

"Sustainability, I mean it's super critical for everyone. It's gone from nice to have to need to have in all companies."

Regarding Hyperloop technology, the expert expressed skepticism about its necessity and effectiveness. He highlighted a common challenge in the investment business, which is identifying the actual problem a new technology aims to solve and whether this problem is perceived as significant by the market. In the context of logistics, the expert questioned what specific issue Hyperloop addresses. He argued that in logistics, lead times are less critical than the ability to plan accurately, trust information, and optimize the network for efficiency. He suggested that the key issues in the logistics sector are emissions, optimization of capacity, and delivery precision, rather than the speed of transportation.

"When it comes to Hyperloop... I don't see a huge need for it, to be honest... What problem are we solving with Hyperloop?"

The expert also addressed the growing demand for quick deliveries, particularly in the e-commerce sector. He doubted the necessity and sustainability of same-day or next-day delivery services, suggesting that most consumer goods do not require immediate delivery. He argued that while some items, like food, may need rapid delivery, many other products can afford longer lead times.

"It's all about the cost... Can you compete on a cost scale?"

He proposed that the cost implications of expedited shipping would likely deter widespread consumer demand for such services. The logistics sector needs to balance quick delivery demands with cost and environmental considerations. Consumers might be willing to opt for slower delivery options if they are incentivized properly.

On the topic of decarbonizing long-haul transportation, the expert suggested shifting from road freight to rail as a viable solution, especially in regions like Sweden with a predominantly fossil-free energy grid. He also mentioned the potential of alternative fuels, such as battery electric vehicles, fusion electric vehicles, and gas-driven vehicles, to reduce emissions. Furthermore, he emphasized the importance of maximizing load capacity and optimizing planning to enhance efficiency and reduce emissions in the logistics chain. When considering the implementation of Hyperloop technology for cargo transport, the expert expressed concerns about its practical integration into existing logistics networks. He stressed the importance of understanding the complete logistics chain and the potential disruptions new technologies could cause. He pointed out the significant infrastructure investments required for Hyperloop and the complexities involved in gaining approvals and right-of-way for new transportation systems.

"The challenge you have with all this infrastructure... you have to have the right of use... pass over people's land."

Additionally, he questioned the economic viability of Hyperloop, emphasizing that any new technology must be cost-competitive, reliable, and seamlessly integrate into existing supply chains to be successful.

In conclusion, the expert reiterated that while reducing the number of trucks on the road could have multiple benefits, including improved road safety, reduced congestion, and better environmental outcomes, the flexibility and existing infrastructure of truck transport present significant challenges to the adoption of alternative technologies like Hyperloop. He highlights that any new logistics technology must clearly demonstrate its economic and operational advantages to gain acceptance among stakeholders in the logistics sector.

The Professor of Transport and System Analysis at KTH University provided insightful perspectives on the viability and challenges of Hyperloop technology. Recognizing its potential for high-speed, low-impact transportation, the professor highlighted significant hurdles in technology, economics, and regulation that must be overcome. Technological advancements in safety, materials, and energy efficiency are crucial, alongside economic models to assess feasibility and funding mechanisms. Academic institutions play a pivotal role in advancing Hyperloop through research, feasibility studies, and systems analysis. Integration into existing transportation systems and public acceptance are key considerations, requiring robust safety measures, transparent communication, and regulatory adaptation. Pilot projects focusing on technical feasibility and public acceptance are recommended, along with urban planning for seamless integration. The future workforce will need diverse skills in engineering, regulation, and communication. He affirms with a belief that the Hyperloop aligns with trends in decarbonization, automation, and urbanization, offering potential for sustainable, integrated transportation networks. Moving forward, continued research, pilot projects, international collaboration, and stakeholder engagement are essential to realize Hyperloop's potential as a transformative transportation solution.

The Senior Project Manager from Trafikverket provided insightful perspectives on the potential integration of Hyperloop technology into Sweden's transportation infrastructure. While acknowledging Hyperloop's promise, the manager emphasized the multifaceted challenges, including cost, regulatory hurdles, and geographical constraints.

"Sweden's terrain and existing urban infrastructure pose unique challenges."

Trafikverket maintains a cautious stance, monitoring international developments but prioritizing practical feasibility over premature adoption. Regulatory engagement is crucial, with Trafikverket participating in EU-level committees to align standards with national regulations. The manager envisions Hyperloop complementing existing systems, particularly for long-distance travel between major cities, alleviating pressure on rail and road networks. Public perception varies, with enthusiasm for technology tempered by concerns over safety, reliability, and environmental impact. From a strategic standpoint, early adoption could enhance Sweden's leadership in transportation innovation and sustainability. Trafikverket advocates collaboration with educational institutions and research bodies to prioritize studies on economic feasibility, environmental impact, and integration challenges, emphasizing the need for joint projects and pilot studies to accelerate development while ensuring regulatory compliance and practical viability. Overall, the manager's insights underscore the importance of careful consideration and collaboration in navigating the complex landscape of Hyperloop implementation.

"Based on current developments, I would say we are at least a decade away."

Lastly, a Member of the IEC 61508 maintenance committee at IEC, whom we interviewed explored the multifaceted potential of Hyperloop technology for cargo transportation within the Nordic region. He emphasized several advantages, notably speed, environmental efficiency, and the adaptability of Hyperloop infrastructure to varying terrains and weather conditions. Additionally, he discussed stakeholder perceptions, noting a shift towards considering both passenger and cargo applications, including potential military use.

Challenges in implementing Hyperloop technology are acknowledged, spanning technological hurdles, financial considerations, and integration with existing transportation systems. Notably, He mentions the need for further research and testing, particularly regarding maglev technology and vacuum systems.

"It is, of course, a big infrastructure project and it will take a lot of money."

Regarding implementation, he envisions a collaborative effort between government entities and private industry, with the government likely taking a leading role due to the high risks and initial investments involved. They suggest starting with cross-border connections between Nordic countries, with potential expansion into broader European networks.

He also highlights the importance of learning from ongoing projects, particularly in the Netherlands, where domestic Hyperloop networks are being explored. This external knowledge could inform the Nordic region's strategy and approach to Hyperloop implementation.

6.2.2 Collation and categorization of Expert views

Aspect	**Optimist View**	**Critical View**	**Skeptical View**
Holistic System View	System dynamics models are essential for understanding transitions.	Requires dynamic models, not linear approaches; complex interactions.	Linear models insufficient; need holistic view to avoid oversights.
Cost-Benefit Analysis	Cost-benefit analysis essential for B2B acceptance.	Early adoption depends on demonstrating reliability and benefits.	Cost-benefit analysis may overlook long-term integration challenges.
Sustainability Goals	Significant driver for adopting electric trucks and Hyperloop.	Regulatory requirements drive the shift towards sustainable transport.	Initial infrastructure CO2 emissions a concern despite long-term benefits.
Technological Awareness	Awareness and familiarity critical for technology acceptance.	Needs demonstration in cargo applications before wider adoption.	Public and stakeholder awareness is low; seen as futuristic and uncertain.
Stakeholder Engagement	Early engagement with stakeholders is crucial for successful transitions.	Without Multi-stakeholder analysis, it's difficult to build confidence and navigate challenges.	Low awareness among stakeholders; requires extensive education efforts.

Infrastructure Compatibility	Integration with existing systems possible with strategic planning.	Intermodal connectivity presents challenges.	Significant integration hurdles; urban infrastructure may not adapt easily.
Economic Viability	Hyperloop is seen as offering speed, capacity, and efficiency advantages.	Economic viability is questioned until technology is proven on a larger scale.	High costs and small logistics margins deter investment.
Regulatory Challenges	Less significant for freight; regulatory bodies starting to engage.	Novelty of technology poses hurdles despite lower perceived challenges.	Significant infrastructure investments and approvals are major hurdles.
Cargo vs. Passenger	Both cargo and passenger applications have potential for impact.	Sole focus on cargo not economically viable	Balanced approach needed for financial sustainability; consumer delivery speed demands questioned.
Long-Haul Solutions	Potential for reducing emissions through alternative fuels and rail.	Shifting to rail viable in regions with fossil-free energy grids.	Hyperloop's integration into existing logistics networks is problematic.
Overall Potential of Hyperloop	Promising solution for sustainable, efficient cargo transport.	Need for comprehensive research on economic and environmental impacts.	Challenges in proving economic viability and practical implementation.

Table 8: Summary of Expert views-Categorization

7. Recommendations and Strategies

There is a recognized demand for Hyperloop technology in Sweden, driven by the country's dispersed population and the need to connect isolated centers of knowledge and expertise. Hyperloop could alleviate geographic constraints and enhance connectivity between Sweden's major cities, leading to significant infrastructure improvements. The concept is supported by members of the Swedish Parliament who argue that, if economically viable, Hyperloop could revolutionize Sweden's transportation network by providing superior regional connectivity compared to existing options. However, several challenges must be addressed before Hyperloop can gain widespread acceptance in Sweden. These include securing insurance, permits, and funding, as well as ensuring the system's maturity and the public's willingness to adopt it. Acceptance is expected to improve significantly once a fully operational system is demonstrated elsewhere, allowing the Swedish public and politicians to experience the technology firsthand. Unlike the U.S., where futuristic marketing can generate excitement, Swedes require tangible proof of Hyperloop's functionality to be convinced of its merits.(Magnusson and Widegren, 2018)

Understanding Hyperloop's impact on travel habits and residential choices is also complex, posing additional barriers to acceptance. The introduction of such disruptive technology involves risks, similar to those faced with the advent of airplanes and automobiles, which initially met with skepticism. Swedish authorities are cautious about investing in new technologies without clear evidence of their practicality and safety. While the Swedish population generally adapts well to new technologies once implemented, the country places a high value on safety and requires comprehensive proof before embracing Hyperloop. The comparison to past infrastructure projects, such as 'Saltsjöbanan' and 'Roslagsbanan', which started with private investment and gradually gained public acceptance, suggests that a similar gradual approach may be necessary for Hyperloop in Sweden.(Magnusson and Widegren, 2018)

We would like to compile our recommendations and strategies based on the valuable insights gained from our lively interactions with the experts. These conversations have provided a deep understanding of the current landscape and the key factors influencing the acceptance of Cargo Hyperloop technology. By synthesizing the expert feedback, we aim to present actionable strategies that address the critical determinants identified, such as perceived value and utility, compatibility with existing infrastructure, regulatory frameworks, technological familiarity, and sustainability.

1. Public Awareness and Education

Develop comprehensive public awareness and educational campaigns to increase familiarity and understanding of Hyperloop technology.

Strategies

Engage with Academic Institutions Partner with universities and research institutions to organize seminars, workshops, and courses on Hyperloop technology. This will leverage the interest and reach of academic events as shown by the survey's finding that the majority of respondents (43.9%) were not aware of the Hyperloop technology.

Utilize Media and Social Media Increase visibility through science and technology news outlets and social media platforms. Targeted campaigns should highlight key technological advancements, sustainability benefits, and operational efficiency of Hyperloop. Social media can also engage younger demographics and tech-savvy professionals, who represent significant portions of the survey respondents.

Public Demonstrations and Pilot Projects Conduct public demonstrations and pilot projects in key locations to showcase the practical benefits of Hyperloop. These projects should focus on real-world applications and provide tangible proof of feasibility, aligning with the need for demonstrable evidence identified in the interviews.

2. Emphasize Sustainability and Environmental Benefits

Highlight Hyperloop’s environmental benefits to align with the strong preference for sustainability among potential adopters.

Strategies

Environmental Impact Reports Publish detailed reports on Hyperloop’s potential to reduce emissions and energy consumption compared to traditional transportation methods. Partnership with consulting firms specialized in such tasks could be beneficial. Emphasize how Hyperloop can meet the sustainability goals of companies and regulatory standards.

3. Address Feasibility and Implementation Concerns

Develop a phased implementation approach and conduct rigorous testing to address concerns about feasibility, safety, and cost-effectiveness.

Strategies:

Pilot and Phased Projects Implement Hyperloop in phases, starting with smaller, manageable routes that can act as proof-of-concept projects. This approach will help address concerns regarding the scientific feasibility and safety of the technology.

Transparent Communication Maintain open communication about the progress, challenges, and solutions related to Hyperloop projects to all the relevant stakeholders. Regular updates through newsletters, reports, and public forums can help build confidence among stakeholders.

Collaborate with Regulators: Work closely with regulatory bodies to understand the end-to-end process of compliance, approvals and legal standards. Early engagement can help navigate potential regulatory challenges more effectively.

4. Integration with Existing Infrastructure

Develop strategies and dialogue forums for integrating Hyperloop with existing transportation systems and its stakeholders to enhance compatibility and reduce its resistance.

Strategies:

Hub-Based Systems Design a hub-based system where Hyperloop integrates with traditional rail networks and other transportation modes for last-mile delivery. This can address intermodal connectivity issues identified in the interviews.

Infrastructure Adaptation Looking for technologies and processes that facilitate the integration of Hyperloop into existing logistics hubs and urban infrastructure. This could involve retrofitting current logistics centers to accommodate Hyperloop systems.

5. Economic and Competitive Viability

Demonstrate the economic benefits and competitive edge of Hyperloop to attract investment and support from the private sector.

Strategies:

Cost-Benefit Analysis Conduct comprehensive cost-benefit analyses, considering both short and long-term accruals of benefits of Hyperloop over traditional transportation methods. Focus on the narrative to reduce operational costs, improve delivery times, and enhance efficiency to gather confidence and reliability of this technology in the testing phase.

Incentives for Early Adopters Incentives such as reduced initial costs or partnerships in early projects to encourage private sector investment by Government could nudge the adoption process by instilling acceptance.

We would now try to incorporate the insights from our Scandinavian study of hyperloop technology for cargo applications, into the framework of the Innovation Diffusion Theory

Characteristic	**Definition** (Sonnenwald et al., 2001)	**Hyperloop Specifics**	**Key Considerations**
Relative Advantage	The degree to which Hyperloop is perceived as superior to existing cargo transport methods in terms of speed, cost, reliability, and environmental impact.	Faster delivery times, lower operating costs, reduced emissions.	**Competitive Edge** Companies/Stakeholders shall weigh the superior performance metrics and decide if the benefits justify the transition.
Compatibility	How well Hyperloop aligns with current logistics systems, infrastructure, and regulatory standards.	Integration with existing logistics hubs, compatibility with current freight standards.	**Infrastructure Integration** Seamless compatibility with existing systems can build confidence towards acceptance, ease the transition and promote adoption
Complexity	The perceived difficulty in understanding and using Hyperloop technology, including technical requirements and necessary skills.	High initial infrastructure investment, advanced technology needs, training requirements.	**Implementation Challenges** Innovative funding model, technological collaboration, sharing and transfer; Skill Incubation for technology, training and awareness
Observability	The visibility of Hyperloop's benefits, such as improved delivery times and environmental impact, to potential adopters and stakeholders.	Demonstrations, pilot projects, and case studies showcasing benefits.	**Market Perception** Market perception is influenced by how visibly the benefits are demonstrated. Successful case studies and pilot

			projects can build confidence among potential adopters.
Trialability	The ability to test Hyperloop technology on a limited scale before full adoption, such as pilot routes or limited cargo types.	Limited scale trials, phased implementation.	**Risk Mitigation** is crucial. Offering phased implementation and trial opportunities can reduce uncertainty and build trust in the technology.

Table 9: Cargo Hyperloop into Innovation Diffusion Theory framework

8. Limitations

The study on the acceptance of cargo Hyperloop technology is subject to several limitations that must be acknowledged.
One significant limitation arises from the representativeness of the sample. Although we aimed to diversify our data collection by including experts from multiple stakeholder perspectives, our study primarily relied on interviews and insights from a limited number of experts in the field. This sample size may not fully represent the breadth of opinions and experiences within the transportation industry. Additionally, the personal biases of the interviewees could have influenced their perspectives on Cargo Hyperloop technology. These biases might arise from their professional backgrounds, personal experiences, or individual preferences, potentially skewing the study's findings.

While the experts interviewed are knowledgeable and experienced, they may not fully represent the diverse viewpoints and expertise found within the broader logistics and transportation sectors. This could limit the generalizability of the study's conclusions, as the perspectives gathered might not reflect the broader industry's stance on Hyperloop technology.

Regulations governing new transportation technologies are still evolving and can vary significantly by region. These regulatory uncertainties pose challenges in predicting how Hyperloop technology will be governed and the extent to which it will be supported or hindered by future policies. This unpredictability can affect the feasibility and attractiveness of Hyperloop as a viable logistics solution.

Hyperloop technology itself is still in the testing and development stages, which introduces significant uncertainty regarding its performance, reliability, and economic viability. As the technology evolves, new challenges and limitations may emerge that were not anticipated during the study. This dependency on a still-maturing technology means that the current findings might not hold true as Hyperloop systems are further developed and refined.

The study's geographic focus on Scandinavia also limits the generalizability of its findings. The logistics infrastructure, regulatory environment, and market dynamics in Scandinavia may differ significantly from those in other regions. As a result, the acceptance and feasibility of cargo Hyperloop technology in Scandinavia might not be indicative of its potential in other parts of the world, where conditions and requirements could vary.

Finally, temporal factors may affect the long-term applicability of the study's findings. The logistics and transportation industries are dynamic, with continuous advancements in technology, shifts in market demands, and evolving regulatory frameworks. What holds true today might not necessarily apply in the future as new innovations emerge and industry standards evolve. Therefore, the study's conclusions should be viewed as a snapshot in time, reflecting the current state of knowledge and industry conditions.

While this study provides valuable insights into the acceptance of cargo Hyperloop technology, these limitations highlight the need for cautious interpretation of the findings and humbly acknowledge the importance of further research as the technology and regulatory landscape continue to develop.

9. Conclusion

The survey and expert interviews reveal a generally favorable view of Hyperloop technology, particularly due to its potential for sustainable and rapid delivery solutions. Enthusiasm varies across demographics; students and professionals display notable excitement, driven by their openness to new technologies and the allure of Hyperloop's innovative characteristics. In contrast, business people exhibit more caution, primarily due to concerns about costs and feasibility. This difference stresses the need to address economic viability and practical concerns to foster broader support. Notably, respondents' strong focus on sustainability aligns with Hyperloop's environmental benefits, suggesting that emphasizing these green credentials could significantly enhance acceptance.

Sustainability and speed emerge as critical preferences. A significant majority of respondents prioritize sustainability in delivery options, aligning with Hyperloop's green credentials. This environmental emphasis indicates a market readiness for Hyperloop's eco-friendly aspects. Additionally, there is a clear demand for faster delivery options, which Hyperloop can potentially fulfill, making it attractive for time-sensitive logistics.

Despite mixed familiarity, there is a substantial need for further education and public engagement. While over half of the respondents are somewhat aware of Hyperloop, enhancing understanding through university events and science/technology news could boost acceptance. Effective communication channels are vital for raising awareness and promoting Hyperloop's benefits.

Concerns about feasibility and integration present notable challenges. Addressing skepticism through transparent communication, rigorous testing, and phased implementation is crucial. Compatibility with existing infrastructure remains a concern, necessitating strategic planning and collaboration with current logistics systems. Demonstrating Hyperloop's economic viability is also essential for gaining support from the private sector, as early adopters and investors seek clear evidence of cost savings and efficiency improvements. Overall, while Hyperloop technology shows significant promise for revolutionizing cargo transportation, concerted efforts in public education, strategic integration, and addressing feasibility concerns are essential for broader acceptance and successful implementation.

During the nascent stages of development and innovation within the hyperloop sector, the Joint Technical Committee 20 (JTC20), set up by the EU has embarked on a mission to establish foundational standards and deliverables that cater to the dynamic needs of this new industry. These standards are to be meticulously crafted to serve multiple purposes: first, they aim to identify and consolidate existing standards relevant to hyperloop technology. Second, they seek to comprehensively understand the requirements and expectations of various stakeholders involved in the hyperloop ecosystem. Additionally, these standards endeavor to delineate the fundamental functionalities inherent to hyperloop systems, providing a robust framework for further advancements.

The deliverables generated by JTC20 would hold significant strategic importance within the hyperloop transportation market. Acting as indispensable tools, they would facilitate technical alignment among diverse stakeholders, paving the way for streamlined collaboration and innovation. Moreover, these deliverables would play a pivotal role in catalyzing the industrialization and commercialization of hyperloop technology, transforming it from a concept into a tangible and economically viable mode of transportation via seamless acceptance amongst all pertinent stakeholders.

Central to the objectives of these standards is the prioritization of critical aspects such as safety, interoperability, and environmental sustainability which should involve proactive participation and exhaustive discussions between all the parties to this technological realization. Recognizing the paramount importance of these considerations, JTC20's work is expected to ensure that the standards encompass comprehensive guidelines and protocols to address them effectively. Furthermore, the standards set forth by JTC20 aim to establish robust testing, verification, and validation processes, ensuring the reliability and integrity of hyperloop systems in real-world applications.

Furthermore, in addition to the hyperloop teams at technical universities, arrangement of and participation in mega events such as European Hyperloop Week can serve as a catalyst for enhancing technical awareness and fostering a collective movement of optimism. Such events provide invaluable platforms for knowledge exchange, collaboration, and showcasing of cutting-edge advancements in hyperloop technology.

By engaging with these communities and events, stakeholders across various sectors can gain insights into the latest developments, challenges, and opportunities within the hyperloop ecosystem. Moreover, these interactions can inspire and mobilize individuals and organizations to actively contribute towards the advancement and adoption of hyperloop technology.

The collective efforts of academia, industry professionals, and enthusiasts nurtured through events like European Hyperloop Week can play a pivotal role in propelling hyperloop technology to the forefront of commercial use. Through collaborative endeavors and shared enthusiasm, stakeholders can collectively drive the necessary innovations, investments, and regulatory frameworks needed to realize the full potential of hyperloop as a transformative mode of transportation.

The European Commission has established an ambitious goal of ensuring that 30 percent of freight tonnage, which travels distances of 300 km or more, utilizes rail or water transportation by 2030. This initiative aims to promote more sustainable modes of freight transport, reducing carbon emissions associated with long-distance hauling. However, achieving this target necessitates a substantial enhancement of Europe's rail infrastructure to accommodate the anticipated increase in rail tonne-kilometers and passenger volumes. While rail transportation is recognized as an eco-friendly alternative to road transport, the required infrastructure expansion entails considerable costs. Additionally, the construction and maintenance of rail infrastructure may incur a significant carbon footprint, undermining the intended carbon mitigation benefits of shifting freight transport to rail or waterways. Thus, while this initiative aligns with environmental objectives, its implementation faces challenges related to cost-effectiveness and environmental sustainability. Offering rapid, energy-efficient transport over long distances, Hyperloop presents an innovative alternative to traditional rail and road networks. With its potential to significantly reduce both travel times and carbon emissions, Hyperloop aligns closely with the Commission's objectives of promoting eco-friendly freight transport. Moreover, its streamlined infrastructure requirements and minimal environmental impact make it an attractive option for achieving the desired modal shift towards rail and water transport.

A strategic approach that emphasizes Hyperloop's innovative and sustainable benefits while transparently addressing feasibility concerns will be essential in gaining broader acceptance and support for this transformative transportation technology. By targeting awareness and educational campaigns through effective channels and engaging with stakeholders' concerns, Hyperloop can pave the way for its successful implementation and adoption.

10. Future Work

The study has provided valuable insights into the acceptance of cargo Hyperloop technology in Scandinavia, shedding light on key determinants and challenges. However, several avenues for future research and exploration emerge from this study:

Longitudinal studies are essential for tracking shifts in public attitudes, perceptions, and acceptance of Hyperloop technology over time. This longitudinal approach allows for the assessment of how public opinion evolves alongside the maturation of the technology and the dissemination of new information.

Policy analysis is vital for examining existing transportation and infrastructure regulations in Scandinavian countries, and potentially the broader *Nordic* region, to determine their compatibility with Hyperloop technology. Identifying regulatory barriers and opportunities for policy interventions will facilitate the seamless integration of Hyperloop into existing transportation systems.

Addressing these research areas will contribute to a deeper understanding of the opportunities and challenges associated with the acceptance of Hyperloop technology and its subsequent implementation in Scandinavia. Moreover, these studies can provide valuable insights for evidence-based decision-making and policy development, supporting the sustainable and equitable deployment of Hyperloop systems in the region and beyond.

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Appendix A

12 Benefits of Hyperloop

Source: Hardt Hyperloop

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 AFFORDABLE HOUSING

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.

05 IMPROVED SAFETY

Challenge: Each year, 1.35 million people are killed on roadways around the world.
Solution: Hyperloop follows a "safe-by-design" approach, prioritizing safety at every step of its development.

06 REDUCED INVESTMENT NEED

Challenge: €50 trillion is required to accommodate demand with traditional modes.
Solution: Hyperloop is faster and easier to build, and provides the highest capacity per investment with 20,000 passengers per hour per direction.

09 REDUCED POLLUTION

Challenge: Transport accounts for 10% of all air pollution.
Solution: Hyperloop will emit no air pollution.

10 REDUCED ENERGY USE

Challenge: Transport energy use will grow by 70% by 2050.
Solution: Hyperloop will use 10 times less energy than road or aviation.

03 IMPROVED TRANSPORT CAPACITY

Challenge: Current infrastructure cannot accommodate the growth in demand of 250% towards 2050.
Solution: Hyperloop provides a high-frequency service with a 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 shielded from external influences and removes human error, minimizing disruptions.

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. An ecosystem of partners is working towards achieving a "net zero economy."

08 REDUCED NITROGEN EMISSION

Challenge: Transport accounts for 67% of all NOx emissions.
Solution: Hyperloop will have no direct NOx emissions.

11 REDUCED NOISE POLLUTION

Challenge: 25% of the EU population is exposed to unacceptable noise and vibration levels.
Solution: Hyperloop will produce minimal noise and vibrations.

12 REDUCED MAINTENANCE COST

Challenge: 50% of infrastructure investment is lost to maintenance.
Solution: Hyperloop will have reduced maintenance costs due to its lack of moving components and frictionless travel.

Appendix B

Carbon Neutrality Vs Net Zero

Carbon neutrality typically refers to balancing out carbon dioxide emissions by investing in projects that reduce or offset an equivalent amount of CO2 elsewhere. This approach often involves activities like planting trees or investing in renewable energy projects. However, it tends to focus solely on CO2 emissions and doesn't necessarily prioritize reducing emissions directly.

On the other hand, net zero is a more ambitious goal that goes beyond just CO2. It aims to achieve a balance between the greenhouse gasses (GHGs) emitted and those removed from the atmosphere. This means not only reducing CO2 emissions but also cutting down on other potent greenhouse gases like methane and nitrous oxide. Net zero targets require companies to set specific goals for reducing emissions across their entire value chains, including both direct and indirect emissions. This comprehensive approach demands rapid and substantial cuts in emissions, often with quantified targets set for shorter timeframes, such as halving emissions by 2030.

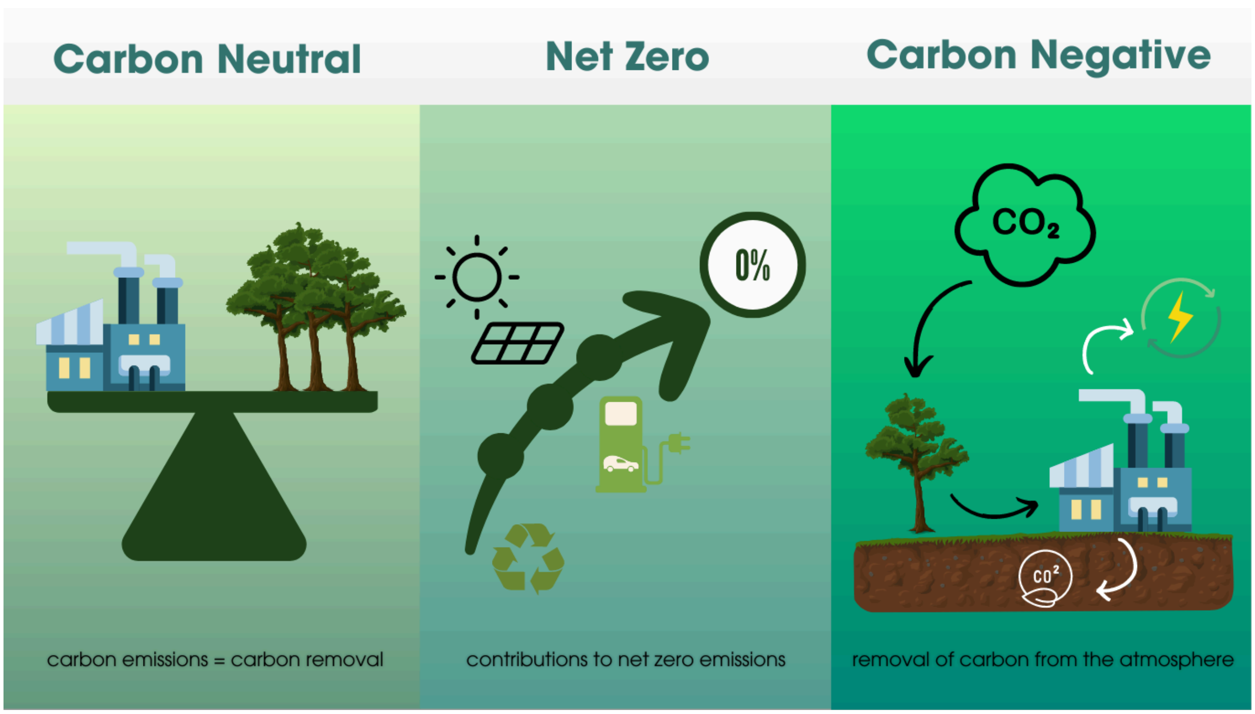
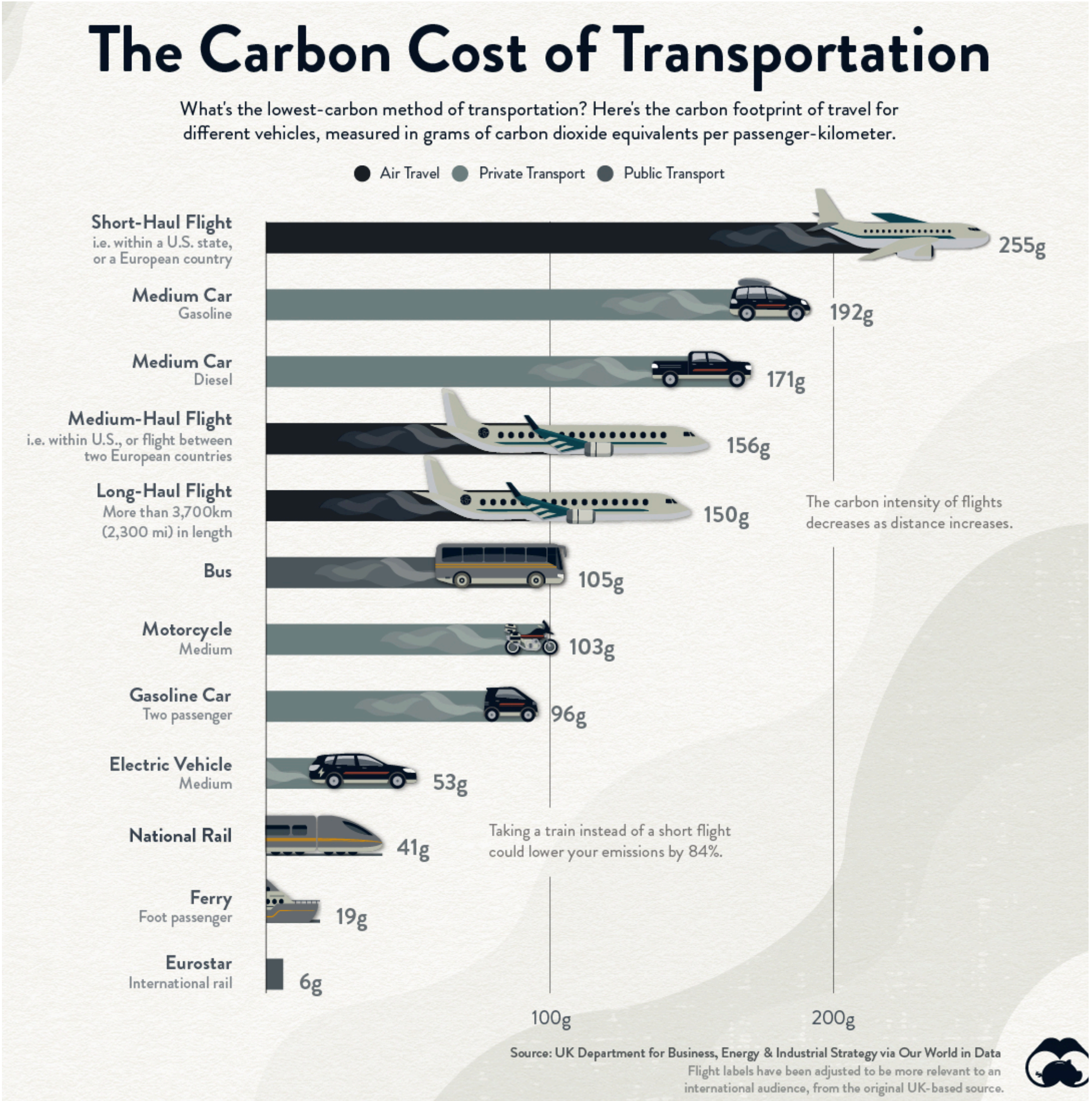


Fig: Source: GreenEco Investments

For more information, please visit
-->https://sciencebasedtargets.org/net-zero
-->https://ge.investments/insights/defining-carbon-emission-commitments-carbon-neutral-net-zero-and-carbon-negative



Source:
https://www.visualcapitalist.com/comparing-the-carbon-footprint-of-transportation-options/google_vignette

Appendix C

Interview Schedule

The names and identities of the expert interviewees have been anonymized as some of the experts requested anonymity.

Interviewee	Description	Interview Date
Expert 1	Leader, Hyperloop Denmark and CEO,Consulting firm	6th March, 2024
Expert 2	Leader, Hyperloop Sweden	27th March, 2024
Expert 3	Supply Chain and Logistics, 10 yrs of experience	2nd April, 2024
Expert 4	Senior Manager, Green Safe Logistics	8th April, 2024
Expert 5	PhD Researcher, Transport, ITRL Lab, Sweden	9th April, 2024
Expert 6	Member of the IEC 61508 maintenance committee at IEC, Norway	26th April, 2024
Expert 7	Professor, (Transport and System Analysis)	9th May,2024
Expert 8	Senior Project Manager, Trafikverket, Swedish Transport Administration	16th May,2024

Link to the Interview Transcripts

https://drive.google.com/file/d/1UJhw0RIKSu6Cq4mhB0BjrIfPOySHoUNu/view?usp=drive_link

Appendix D

Interview Questions

We adopted a structured interview approach, starting with core questions designed to directly address our main and sub-research questions. These questions aimed to gather essential insights related to the acceptance of Cargo Hyperloop in the Nordic region. Depending on the interviewee's competence and experience, we followed up with counter-questions to delve deeper into specific aspects or clarify responses. This iterative questioning technique allowed us to adapt the conversation dynamically, ensuring that we captured a comprehensive understanding of the topic from various expert perspectives.

>>Schema of some core questions

Perceived Value & Utility
Q. How do you perceive hyperloop technology for cargo movement? Does it offer sustainable advantages over the necessary technologies? If yes, what are they; if no, why do you believe so?
Economy
Efficiency
Accessibility
Equity

Q. What are the pertinent issues in the logistics sector? Do you believe hyperloop technology can solve this problem?

Regulatory Framework
Q. Do you foresee any regulatory challenges while implementing this technology? What are the necessary frameworks that will require decision makers to implement this technology?
Q. How do stakeholders, particularly the decision makers perceive this technology?

Sustainability
Q. How important is transitioning towards sustainability in your business model? What are your thoughts about hyperloop for cargo transportation and sustainability?

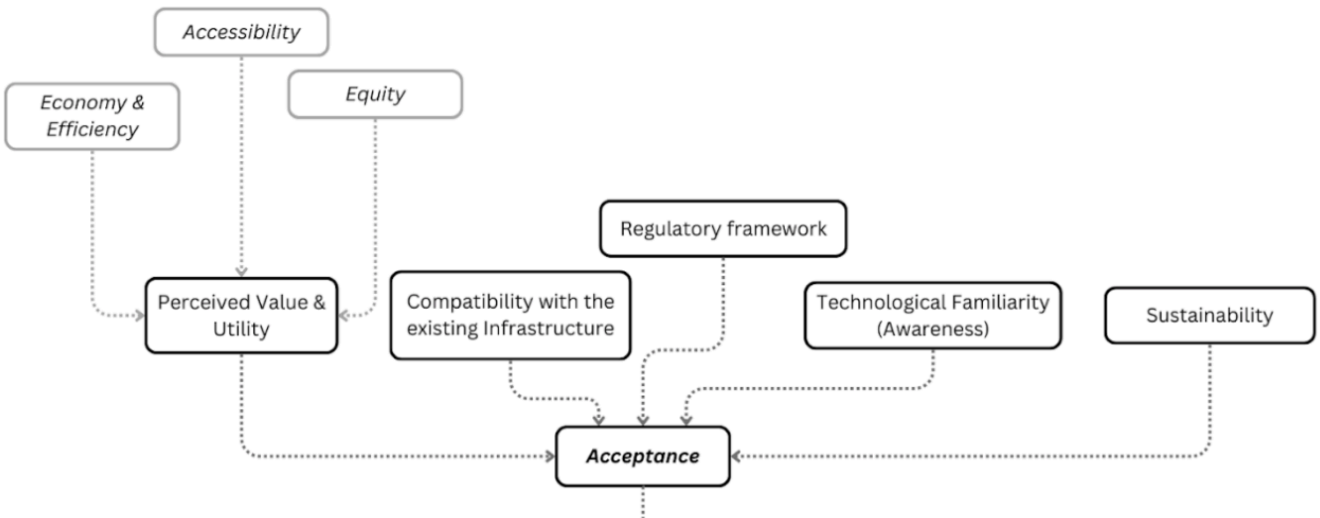
Compatibility with the existing infrastructure
Q. What are the challenges that you see in implementing hyperloop technology with existing infrastructure?
Q.What about hyperloop for cargo transportation?

Technological familiarity
Q. To what extent the general public is aware of hyperloop technology today?
Q. How familiar are the technological advancement of hyperloop among different stakeholders including the public and private sector?

Appendix E

Acceptance Score Form

Cargo Hyperloop



Using the model provided above for assessing the acceptance of Cargo Hyperloop, please allocate and distribute scores to each of the following five determinants, ensuring that the total score points sum up to 100.

Assign higher scores to the determinants you consider more significant for the technology's acceptance by stakeholders.

1.Perceived Value & Utility: This factor indicates how much stakeholders perceive the benefits and usefulness of Cargo Hyperloop. If the technology offers significant advantages such as speed, efficiency, and cost-effectiveness, it's more likely to be accepted.

Economy & Efficiency:In the context of cargo hyperloop, economy refers to the cost-effectiveness of implementing and operating the system. Efficiency refers to how well the hyperloop system utilizes resources such as energy and time to transport cargo. Stakeholders would consider the economy and efficiency of cargo hyperloop in terms of its ability to reduce transportation costs, increase productivity, and optimize resource usage.

Accessibility: Accessibility refers to the degree to which the cargo hyperloop system is available and usable to various stakeholders, including businesses, industries, and communities. It involves factors such as geographical coverage, ease of access to hyperloop terminals, and affordability of using the system.

Equity: Equity concerns the fairness and impartiality in the distribution of benefits and burdens associated with cargo hyperloop. It involves ensuring that the advantages of the hyperloop system are shared equitably among different stakeholders, regardless of factors such as geographical location or socioeconomic status.

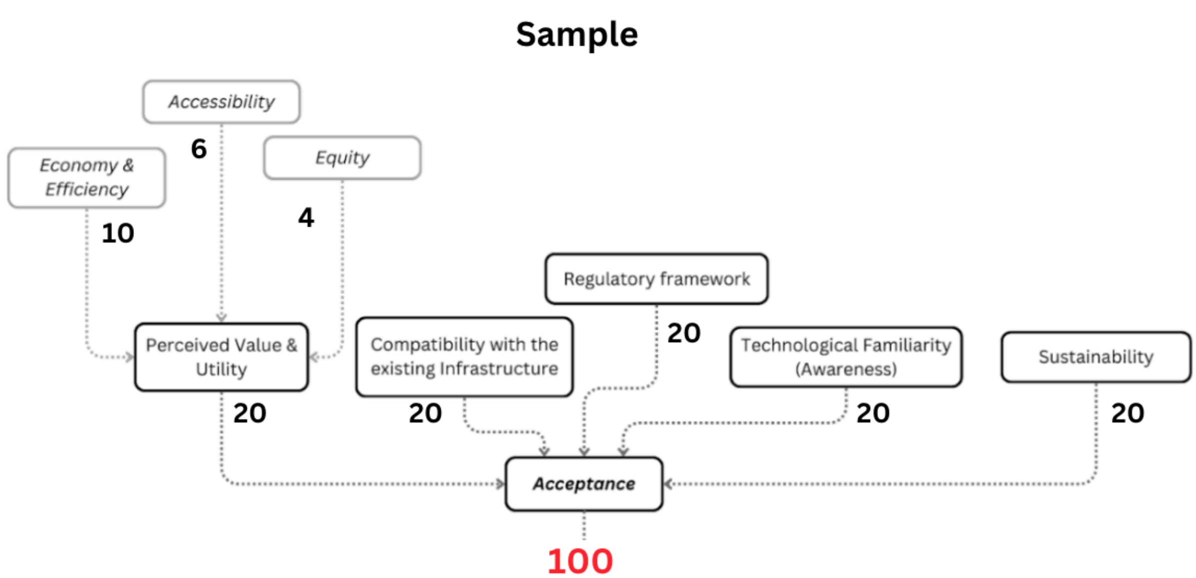
2. Compatibility with the Existing Infrastructure: The degree to which the Hyperloop system can integrate with and complement existing transportation infrastructure is crucial. Higher compatibility is presumed to reduce the acceptance & implementation barriers and resistance from stakeholders.

3. Regulatory framework: Regulations play a significant role in the acceptance and adoption of new technologies. A supportive regulatory environment can facilitate the implementation of Cargo Hyperloop by providing necessary permits, safety standards, and legal frameworks.

4. Technological Familiarity: Stakeholders' familiarity and comfort with the underlying technology are key factors influencing acceptance. If the technology behind the Cargo Hyperloop is well-understood,demonstrated and proven, it will likely garner more support.

5. Sustainability: In today's world, sustainability is increasingly becoming a crucial consideration. The degree to which Cargo Hyperloop addresses environmental concerns, such as reducing carbon emissions and energy consumption,particularly from the transportation sector, will influence its acceptance.

One sample allocation is done for you
Note: The sample below is just for illustration purpose



Please Allocate your score for each of the Major Determinants. (Note: Total should be 100)

	Perceived Value & Utility	Compatibility with the Existing Infrastructure	Regulatory framework	Technological Familiarity	Sustainability
Score					

Allocate your score for each of the sub determinants of Perceived Value & Utility aspect of the Cargo Hyperloop (Note: Total should be equal to the score you gave to the Perceived Value & Utility determinant in the previous table)

	Economy & Efficiency	Accessibility	Equity
Score			

Link to the form above: https://eu.jotform.com/form/240655653829062

Note: Initially, we interviewed EIGHT experts. However, to enhance our Acceptance form responses, we leveraged the professional networks of these initial experts to include THREE additional respondents. Consequently, we consulted a total of eleven experts, who gave relative weights to various acceptance parameters in the aforementioned form

Results:

Expert Respondent	Perceived Value & Utility	Compatibility with Existing Infrastructure	Regulatory Framework	Technological Familiarity	Sustainability
1	40	20	10	5	25
2	50	25	10	5	10
3	55	15	10	10	10
4	45	10	15	5	25
5	60	20	5	5	10
6	50	20	7	7	16
7	45	15	15	5	20
8	55	20	5	5	15
9	50	20	5	5	20
10	50	20	0	2	28
11	40	25	10	5	20
Average	49.1	19.1	8.4	5.4	18.1

Expert Respondent	Economy & Efficiency	Accessibility	Equity
1	20	10	10
2	30	15	5
3	35	15	5
4	20	15	10
5	40	10	10
6	20	15	15

7	15	15	15
8	20	20	15
9	24	16	10
10	40	5	10
11	18	12	10

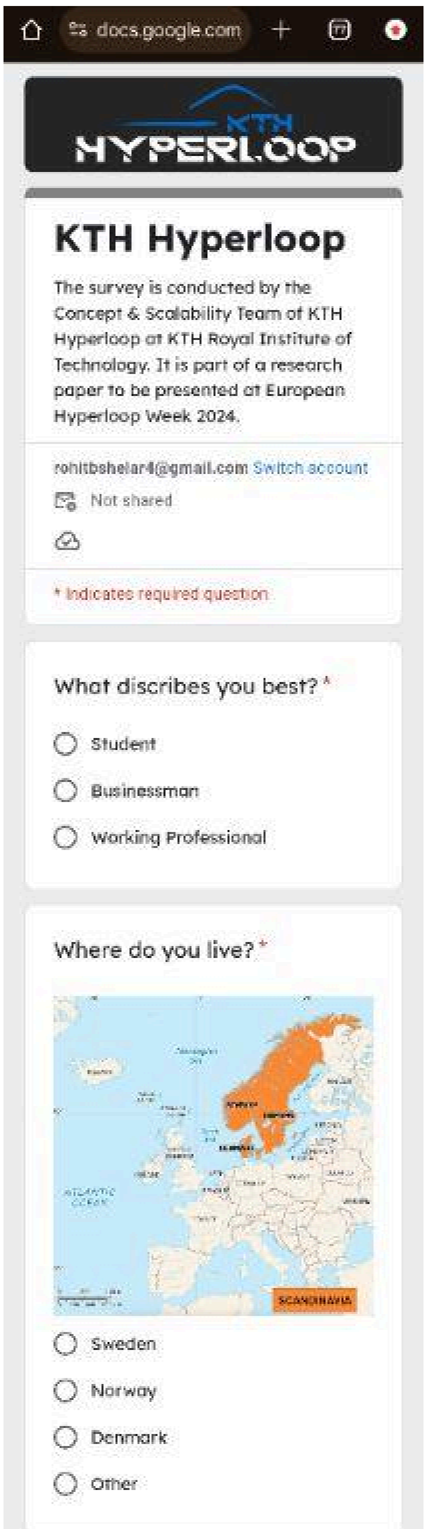
Converting the Perceived Value & Utility Responses into Individual Percentages

Expert Respondent	Economy & Efficiency(%)	Accessibility(%)	Equity(%)
1	50.0	25.0	25.0
2	60.0	30.0	10.0
3	63.6	27.3	9.1
4	44.4	33.3	22.2
5	66.7	16.7	16.7
6	40.0	30.0	30.0
7	33.3	33.3	33.3
8	36.4	36.4	27.3
9	48.0	32.0	20.0
10	72.7	9.1	18.2
11	45.0	30.0	25.0
Average	50.9	27.6	21.5

Appendix F

General Awareness Survey

Link:
https://docs.google.com/forms/d/e/1FAIpQLSe0ra85TnbDpwrc2DlB8t1mkYqbhUSMH54Y0NzPylrx4nSx1A/viewform?usp=sf_link (*Survey is now closed for responses)*



docs.google.com

KTH HYPERLOOP

KTH Hyperloop

The survey is conducted by the Concept & Scalability Team of KTH Hyperloop at KTH Royal Institute of Technology. It is part of a research paper to be presented at European Hyperloop Week 2024.

rohitbshelar4@gmail.com Switch account

Not shared

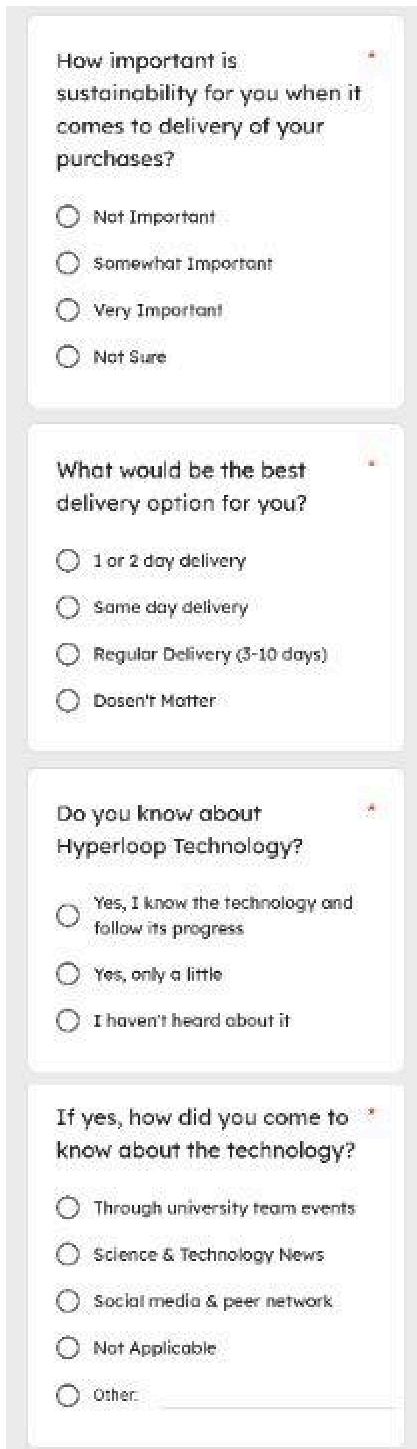
* Indicates required question

What discribes you best? *

- Student
- Businessman
- Working Professional

Where do you live? *

- Sweden
- Norway
- Denmark
- Other



How important is sustainability for you when it comes to delivery of your purchases? *

- Not Important
- Somewhat Important
- Very Important
- Not Sure

What would be the best delivery option for you? *

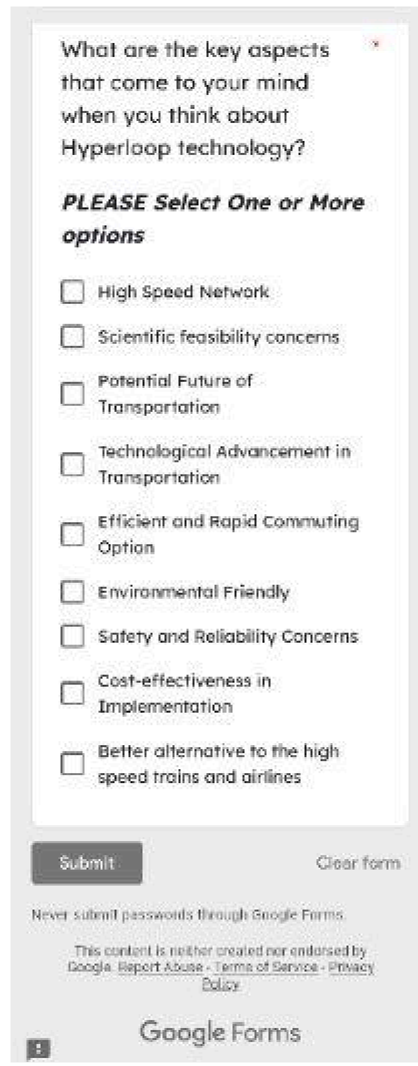
- 1 or 2 day delivery
- Same day delivery
- Regular Delivery (3-10 days)
- Dosen't Matter

Do you know about Hyperloop Technology? *

- Yes, I know the technology and follow its progress
- Yes, only a little
- I haven't heard about it

If yes, how did you come to know about the technology? *

- Through university team events
- Science & Technology News
- Social media & peer network
- Not Applicable
- Other:



What are the key aspects that come to your mind when you think about Hyperloop technology? *

PLEASE Select One or More options

- High Speed Network
- Scientific feasibility concerns
- Potential Future of Transportation
- Technological Advancement in Transportation
- Efficient and Rapid Commuting Option
- Environmental Friendly
- Safety and Reliability Concerns
- Cost-effectiveness in Implementation
- Better alternative to the high speed trains and airlines

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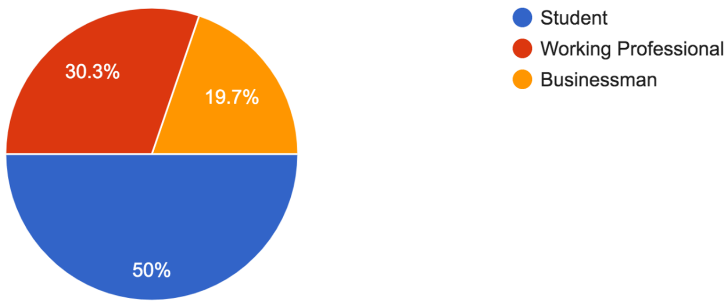
Survey Results in Detail

Question wise

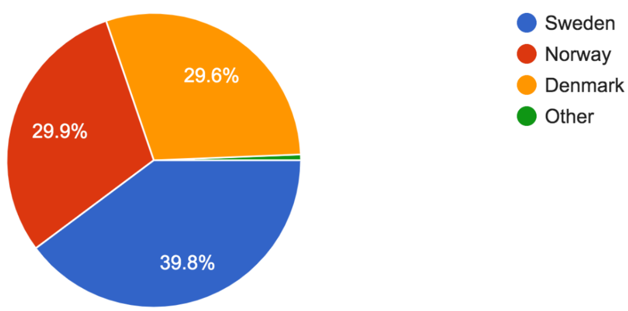
1.What describes you best?

314 responses



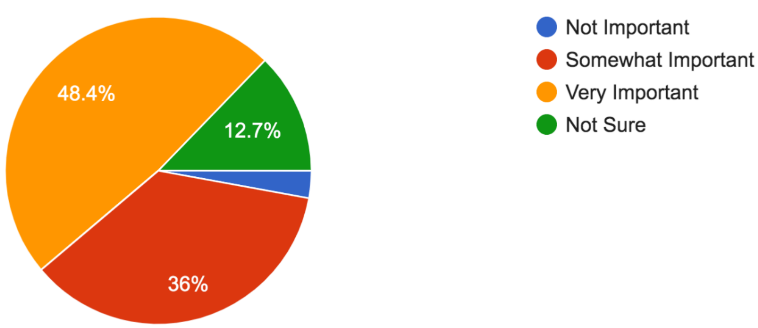
2.Where do you live?

314 responses

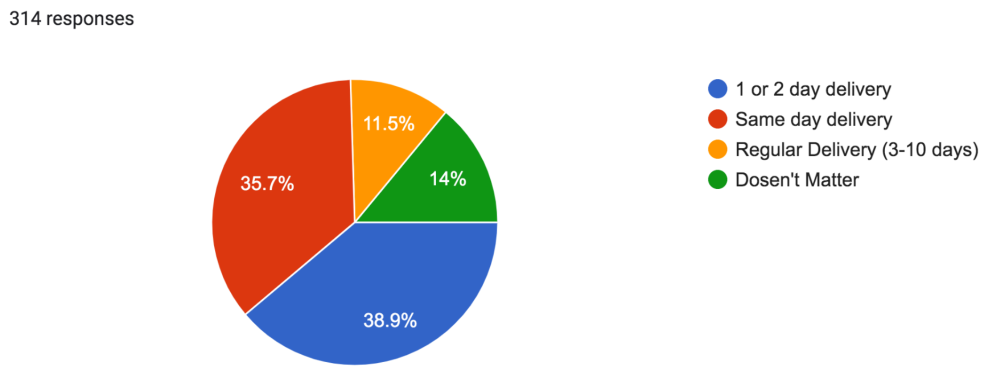


3.How important is sustainability for you when it comes to delivery of your purchases?

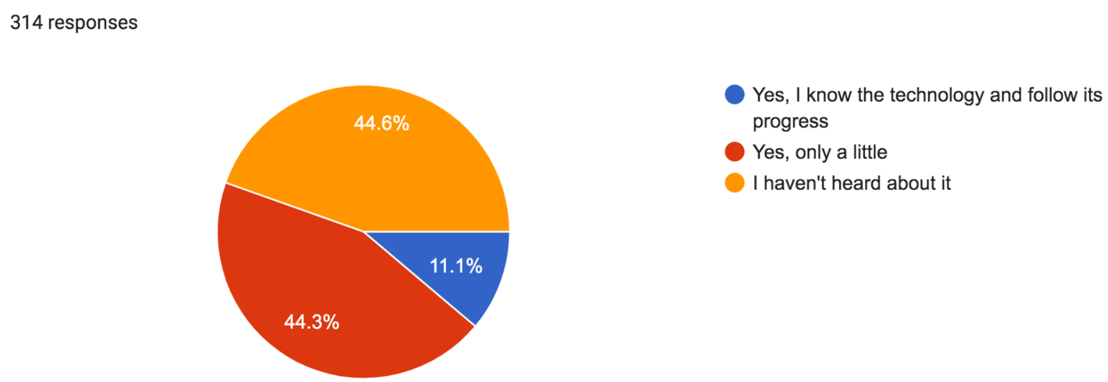
314 responses



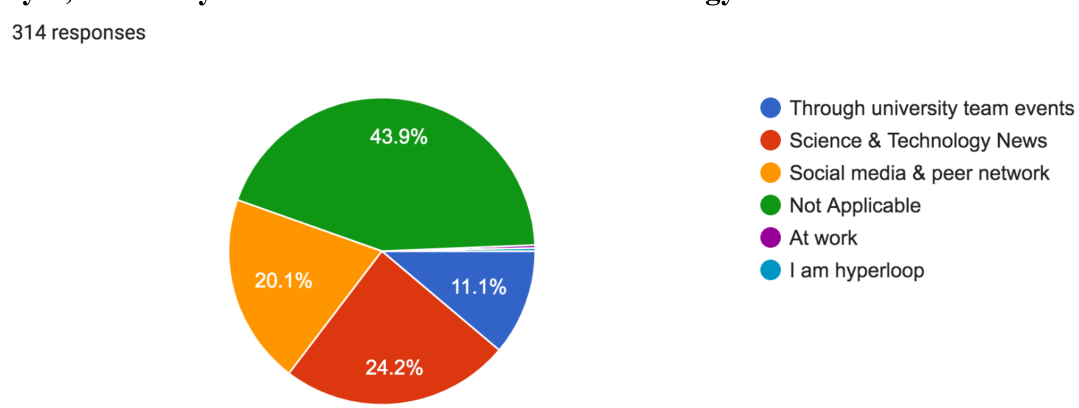
4.What would be the best delivery option for you?



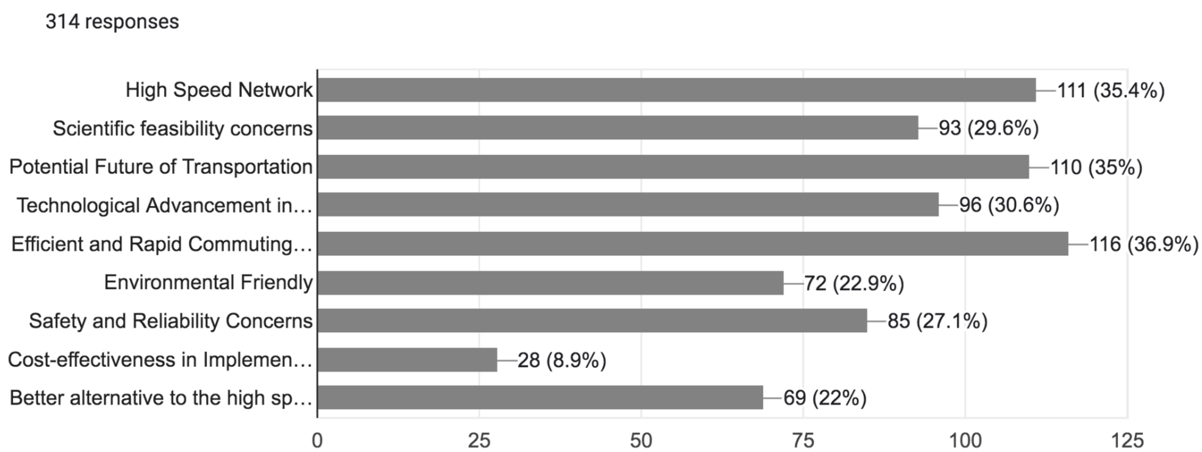
5.Do you know about Hyperloop Technology?



6.If yes, how did you come to know about the technology?



7.What are the key aspects that come to your mind when you think about Hyperloop technology?
PLEASE Select One or More options



Link to excel file of the responses
https://docs.google.com/spreadsheets/d/1astfNJyF4JBR_TFzNsE3oHb6YekkLySKFwVbqQZWIV8/edit?usp=sharing