Queen's University
Kingston, Ontario, Canada

Socio-Economic Research and Analysis of TransPod and Various Hyperloop Projects Around the World

Design Team Research Paper (European Hyperloop Week 2023)

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Statement of Originality and Contribution

Following professional engineering practice, we bear the burden of proof for original work. We confirm that this work is original, and sources are cited appropriately whenever used.

Members of this paper are from the Business Competitions team within Queen's Hyperloop: a group of design team members with diverse backgrounds in the fields of engineering, commerce, and health sciences. The main purpose of this team is to conduct non-technical research and analysis of Hyperloop systems.

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Wendy Li	Queen's Hyperloop Design Team	Usage of Hyperloop in Ports, Application of Replacing Trucks	Usage of Hyperloop in Ports, Application of Replacing Trucks	Usage of Hyperloop in Ports, Application of Replacing Trucks

Abstract

Research Question

Ever since the first iteration of modern Hyperloop pods, the technology behind this impactful concept has significantly developed. However, outside of the technical realm, questions about the social, economic, and healthcare impacts of Hyperloop systems remain unanswered. In this report, the team explores various topics beyond the technical design and development of pods and relevant infrastructure to answer the big question: What are the socio-economic problems and trends we currently face, and how can we deal with them?

Brief Overview of Motivation

The principal motivation for this socioeconomic research of Hyperloop revolves around ensuring that its technical prowess does not overshadow the potential (negative) impacts on social welfare. As Hyperloop is speculated to soon become reality, its transition and integration into daily life may not yet be something society has adequately prepared for. Consequently, QHDT was motivated to thoroughly analyze its socioeconomic benefits and drawbacks, finding ways to facilitate a near-seamless integration of Hyperloop into daily life.

Presentation of Results

The research findings reveal significant socio-economic implications of implementing Hyperloop. Current advances demonstrate that Hyperloop technologies can enhance regional connectivity by dramatically reducing transportation times, with the power to even redefine urban development. Aside from passengers, Hyperloop can facilitate more rapid freight transportation, resulting in added macroeconomic benefit through the considerable time saved on transportation.

However, one key negative impact is its sheer strain on public finances, particularly due to high initial infrastructure costs. Additionally, there may be issues surrounding Hyperloop's financial accessibility since its heavy initial costs will likely trickle down to citizens. Furthermore, the construction of Hyperloop networks may displace residents of lower-income or rural areas, reflecting inequality in how Hyperloop may disproportionately benefit certain subsets of the population. Overall, these mixed findings reflect the complex socio-economic impacts of Hyperloop, highlighting the importance of planning before its thorough implementation.

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General

Description

Queen's Hyperloop Design Team (QHDT) is a dynamic group of over 150 passionate students hailing from Queen's University in Kingston, Ontario. The team shares a vision to change the future of transportation and is committed to pushing the boundaries of innovation and engineering excellence, by leveraging interdisciplinary collaboration amongst the immense talent pool within Queen's University. This paper serves as a testament to the collective dedication and progress achieved in our journey towards making Hyperloop a reality. QHDT is a partner of the Canadian Hyperloop Conference (now Hyperloop Global) – the team also competed in this annual competition that was held in May 2023.

As Hyperloop rapidly advances to hold the status of a viable transportation mode, increasing attention has been directed toward its societal implications. Since early 2023, QHDT has focused on team expansion to encompass students from a broader range of disciplines and faculties to research non-technical issues and other aspects related to Hyperloop. This paper is a product of several months of research and consultations with stakeholders within Hyperloop, as the team seeks to formulate solutions that enable a seamless implementation of Hyperloop in everyday life.

Hyperloop systems involve a complex combination of business strategies and technology, giving rise to a wide range of challenges that extend beyond the technical realm. Topics such as financial planning and revenue generation hold a significant influence over the decision-making processes of Hyperloop initiatives. Therefore, it's imperative to engage in comprehensive discussions that are aimed at investigating and generating solutions for non-technical problems surrounding Hyperloop systems. Doing so will enable the effective management of evidence-based decision-making processes for these non-technical aspects.

The topics within our analysis provide a review of current progress and future potential for healthcare, economic development, and social security improvements within the Hyperloop industry. This paper delves into both Canadian and international projects, focusing on successful achievements and previous failures. Ultimately, readers will gain a strong understanding of the current Hyperloop industry and its market trends via evidence-based research.

Environment & Objectives

The team's primary objective is to evaluate the feasibility of Hyperloop implementation through a socio-economic lens. Despite the unprecedented transportation milestones that Hyperloop may achieve, a prevailing consensus has emerged over the years that expresses concerns regarding the expected drawbacks associated with its implementation. This report aims to validate potential concerns regarding Hyperloop, identify mitigation solutions, and optimize this groundbreaking mode of transportation for day-to-day life.

In recent years, the Hyperloop industry has concentrated on the technological aspects behind its infrastructure and passenger/cargo pods. However, as ongoing large-scale projects progress beyond the initial California proposals, the opportunity to investigate the non-technical dimensions of Hyperloop's technology is now available. Queen's Hyperloop has assembled a team of business and technology analysts from diverse backgrounds to tackle this specific challenge, to provide readers with greater insight into the various socio-economic factors that will likely dominate the conversation of Hyperloop systems in the future.

Domestically, TransPod, a Toronto-based Canadian Hyperloop company, has embarked on an Hyperloop project connecting the Albertan cities of Calgary and Edmonton, as shown in Figure 1.

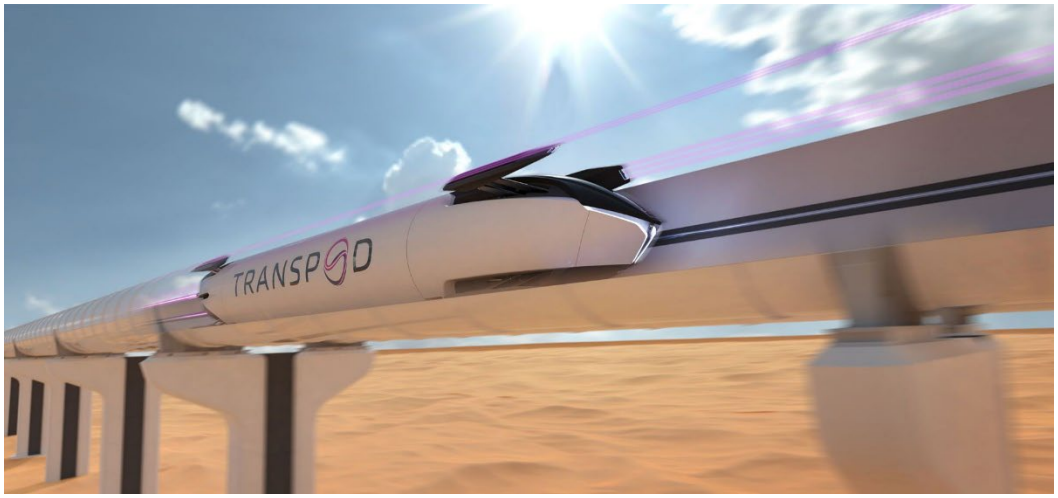

Figure 1: Rendered concept picture of TransPod's Hyperloop system.

The team plans to research and analyze the company's decision-making rationale to understand and generate a general evaluation of modern Hyperloop systems. This will pave the path to conduct similar investigations and evaluations across international Hyperloop projects on topics such as passenger safety, economic effects of Hyperloop systems, and infrastructure planning.

While these topics cover a diverse range of industries that may not directly connect, they will support the understanding of the business and technology behind Hyperloop systems.

The strategy and methodology used to gather information for this paper has been centered around literature review and interviews. Online sources have been leveraged to gather information and evidence on identified topics and interviews were viewed and conducted to gain perspective from additional sources. Internal discussions regarding research and analysis were conducted to provide feedback and insights from team members' personal backgrounds. Finally, the discussions that took place during the Canadian Hyperloop Conference in 2023 were also used to further enhance the accuracy of this paper.

Research

Introduction

Topic & Motivation

Non-technical and socio-economic Hyperloop topics cover a wide range of problems within the industry, all of which contribute to the current state of Hyperloop technology and its trends. This report covers topics related to the economic aspects of Hyperloop projects, the development potential of Hyperloop systems in various locations, environmental considerations and impacts of Hyperloop infrastructure, monetization of Hyperloop systems, and global comparisons of Hyperloop systems in different parts of the world. Each topic has its own introduction, discussion, results, and analysis, presenting potential solutions to the problems identified. Various sources and statistics are presented to provide a better understanding of the topics and serve as evidence for research and discussion.

The main motivation behind these investigations is to gain a better understanding of the current socio-economic landscape of various Hyperloop projects around the world. This understanding can help address potential problems and generate awareness. Hyperloop systems are complex, and the industry encompasses a wide spectrum of elements. Therefore, the team aims to provide the reader with a comprehensive list of topics that offer insights into as many aspects of Hyperloop systems as possible.

Economic Accessibility

As the Hyperloop presents the future of high-speed travel, our societies have a responsibility to address the economic repercussions of this revolutionary technology. While the Hyperloop promises an exciting future of high-tech, time saving transportation we must consider the following questions: Will the Hyperloop be accessible for all socio-economic communities? How will we ensure that the Hyperloop does not create greater economic inequalities? Will the Hyperloop be profitable enough to benefit our society as a whole? In this report, we will dive into these questions, exploring the various factors that will influence the economic accessibility of the Hyperloop and considering the potential societal impacts. Our goal is to provide a comprehensive examination of the Hyperloop, not only as a technological innovation but also as a potential game-changer that could redefine society's norms.

Redefining Urban Development

The Hyperloop holds immense promise for redefining urban development, drawing inspiration from the successes of high-speed rail (HSR) systems, particularly in Japan. By analyzing the key factors that contributed to the success of the Japanese HSR system, such as location, speed, and safety, we can draw parallels to an Hyperloop system and envision a future where it surpasses the capabilities of HSR. Redefining urban development involves leveraging the time-saving benefits of Hyperloop travel, its impact on education and housing, the potential to alleviate congestion in cities, and its role in promoting sustainable travel. By examining these facets, we can gain a comprehensive understanding of how Hyperloop technology has the potential to redefine the landscape of urban development and offer viable solutions to challenges faced by modern cities.

Hyperloop For E-Commerce

As the e-commerce industry continues to grow, customers expect increasingly quick and on-demand delivery, which has prompted businesses to seek fast and efficient delivery systems. Currently, e-commerce operations rely heavily on the trucking industry. Transitioning to an Hyperloop system would offer many advantages that could benefit both customers and businesses. These advantages include expedited delivery, reduced emissions, decreased road and air congestion associated with e-commerce activities, improved service for online businesses, and cost savings through increased delivery volume within shorter timeframes.

Usage of Hyperloop in Ports

Hyperloop has the potential to significantly improve the efficiency and operations of current ports through its high-speed pods. By integrating Hyperloop technology into dense ports, goods can be seamlessly transported within the port premises, replacing traditional methods such as trucks or trains. This eliminates the need for extensive trucking operations and alleviates congestion on roads and rail networks. With Hyperloop, ports can experience optimized supply chains, reduced costs, and increased sustainability.

Application of Replacing Trucks

Through Hyperloop's high-speed underground transit network, cargo transport can be effectively optimized compared to current traditional alternatives such as trucks. As of 2019, trucks accounted for approximately 72.5% of America's freight by weight and represented 80.4% of the national freight bill [1]. Hyperloop offers a sustainable alternative to trucks, while significantly

reducing transit times and optimizing the supply chain by enabling uninterrupted transit within an underground network. Additionally, Hyperloop can alleviate road congestion and reduce traffic accidents, considering the 49% increase in fatal crashes involving large trucks over the last 10 years [2].

A Comparative Analysis of Hyperloop Systems in Turkey and Canada

In an era of revolutionary transportation, how can we ensure the feasibility of technology in all parts of the world? Considering factors such as geography, economics, and government interests, how can they influence the integration and feasibility of the Hyperloop system? In this section, we will highlight the key differences between Turkey and Canada to explore how these factors can shape opportunities. From Canada's increasing demand for forestry to Turkey's seismic region, this section will examine how different factors impact the successful integration of the Hyperloop. By exploring these differences and similarities, we can gain insights into how Hyperloop adoption can vary across different regions, bringing us closer to achieving interconnected and efficient forms of transportation.

Physical Accessibility

In recent years, Hyperloop technology has generated anticipation as an exciting new mode of transportation. However, is it accessible for everyone? This section of the report will explore the issues of physical accessibility that may arise with this technology and potential solutions for creating an inclusive and accessible Hyperloop system. Considering previous models like TransPod, as well as current laws and regulations in place, what are some key considerations and recommendations for ensuring that everyone can access this revolutionary form of transportation?

Environmental Impacts of Hyperloop

While Hyperloop can offer several advantages, especially for passengers and cargo, due to its high speeds, it is crucial to assess the environmental impacts of this innovative mode of transportation. It is important to consider both the potential benefits and the consequences that may arise. When evaluating the implementation of Hyperloop in cities, it is necessary to go beyond the usual assessment of environmental effects such as emissions and energy consumption. Factos such as land use, potential habitat destruction, noise pollution, visual eyesores, as well as waste generation should all be taken into consideration when evaluating this new technology.

Redefining Global and Domestic Interconnectivity

Hyperloop systems accomplish the remarkable feat of significantly reducing the distance between entire cities. Capable of attaining speeds exceeding 1,000 km per hour and operating every 2 minutes, a single pod can transport either 28 passengers or 10 tons of cargo swiftly and efficiently between city centers [3]. The advent of unprecedented travel efficiency between two cities will revolutionize their dynamics. Individuals can now reside and work in different cities while effortlessly commuting between them for both business and leisure purposes. This newfound mobility empowers businesses to expand their operational scope and tap into a broader talent pool. Moreover, freight operations will undergo optimization as these systems not only reduce shipping time and costs but also redefine the way cities receive their goods. For instance, landlocked cities can now receive freight via hyperloop from port cities, replacing traditional methods such as air or truck transportation. The seamless connectivity between cities will also lead to a significant boost in tourism, as travelers can easily explore and experience both destinations with unparalleled ease and convenience.

Population Density and High-Speed Transportation

When assessing the potential success of a hyperloop system, one crucial factor to consider is the population density of the cities involved. The proximity of individuals to city centers plays a significant role in determining the likelihood of project success, as it directly impacts commute times. To understand the importance of population density and the potential effects of Hyperloop on cities' population density, Japan's high-speed rail (HSR) system can serve as a reference point.

Japan, with its population density of 347 people per km², boasts nine HSR systems spanning over 30,000 km across the country [4]. In contrast, the United States, with a population density of 36 people per km², has only one high-speed rail service—Amtrak's Acela [5]. Despite the US having over 2,500% more land mass than Japan, the denser population of Japan's cities results in a more extensive utilization of high-speed transportation.

Introducing a high-speed transportation mode to a city initiates a shift in urban development patterns. Instead of expanding outward, cities begin to "grow up." The fast and convenient intercity connections encourage people to reside near city centers, not only to take advantage of quick travel to other cities but also due to the subsequent development and economic opportunities that arise in the connected city centers.

These interconnections bring substantial financial investments and business activities to the economy, consequently increasing the value of residing near the city center. As a result, the introduction of high-speed transportation has a transformative effect on urban dynamics, shaping the way cities evolve and prompting a concentration of population and economic activities in city centers [6].

Background Information

Hyperloop & Public Perception

The Hyperloop is a proposed mode of ultra-rapid passenger and freight transportation, popularized by entrepreneur Elon Musk in 2013. Hyperloop systems consist of three core elements: tubes, pods, and terminals. The concept involves a sealed tube system with extremely low air pressure, having the potential to exceed airplane speeds. Currently, Hyperloop technology is still largely experimental, with various companies (such as TransPod) conducting research on its practical development. However, due to the challenges of maintaining vacuums over long distances, there has been general hesitancy to fully implement Hyperloop.

In 2021, Morning Consult conducted a survey to gauge public perception of hyperloop systems. Given the substantial investment costs associated with this new generation of tube transportation, public opinion is incredibly important to ensure feasibility in profit margins [7]. Safety and reliability emerged as the biggest concerns for potential consumers, with over 73% of respondents expressing concern in these areas [7]. Subsequently, it is not surprising that 71% of respondents said they would prefer driving their own car when commuting [7].

Initially, 1% of respondents listed Hyperloop as their preferred commuting method [7]. However, after respondents were provided with more information about hyperloop systems, this number rose to 13% [7]. However, less than 50% of surveyed adults supported the use of taxpayer money to fund hyperloop tracks [7]. This is compared to over 60% who supported the use of public funds to finance roads, bridges, and public transportation [7].

TransPod Overview

TransPod was founded in Canada in 2015 by Sebastien Gendron and Dr. Ryan Janzen, with a vision of introducing a new generation of tube transportation by harnessing emerging technologies to create a safe and sustainable high-speed transportation system [8]. As this new technology has advanced, it has become a prominent solution to address the express freight

market's high demand challenges. TransPod's "FluxJet" system can travel at speeds of up to 1000 km/hr, connecting industrial areas 500 km away from each other in less than one hour [8].

Compared to air cargo and truck transport, TransPod also presents a significantly lower environmental threat. TransPod has a vision to completely automate the express freight market, subsequently reducing carbon emissions associated with the supply chain. The payload capacity of each transport pod facilitates automated loading and unloading, and the pod terminals are designed to seamlessly integrate with automated last-mile systems including drones, driverless-trucks, and automated ground vehicles.

TransPod is currently partnered with Alberta Transportation to study the feasibility of a TransPod system traveling between Calgary and Edmonton, a 300 km distance across relatively flat and uninterrupted terrain [8]. Typically, most Albertans travel this distance by car, which takes over three hours. Flights – the second most common mode of transportation – take a similar duration, when also considering airport time. On a TransPod train, this time would be reduced to just one hour [8].

The construction of this project would cost an estimated $22.4 billion (CAD), translating to $45.1 MM (CAD) per kilometer of track plus an additional $6.7 billion (CAD) for the construction of terminals and other indirect costs [9]. In comparison, a similar path of a high-speed rail traveling at 400 km/hr would cost $9 billion (CAD) [9]. Despite these high costs, TransPod has secured $550 MM in funding, a relatively small portion of the overall project costs [9]. TransPod is expecting most of their funding to come from private institutions that see the long-term financial gains of the project.

Although TransPod's target market is currently express freight, they still have a long-term vision for passenger travel. Along this Albertan track, a ticket from Calgary to Edmonton would cost $90, which the company claims are low enough to ensure accessibility to the masses while still allowing them to operate at a net gain [9].

E-Commerce & Transportation

Through the height of the COVID-19 Pandemic, ecommerce sales in Canada rose from 3.9% in 2019 to 6.9% in 2021 [10]. Even though pandemic restrictions have been eased, ecommerce sales continue to remain on this upward trend, reaching 6.2% in July of 2022 [10]. With these trends comes an increased demand for express freight. Same-day and express shipping are

becoming a consumer expectation and are therefore vital features for a company to remain competitive. Currently, air cargo is the most used delivery system for the express freight market, followed by truck transport. However, with air cargo becoming increasingly constrained by government regulations, concerns have been raised about the industry's ability to meet the market's escalating demand.

Methodology

The main guideline for conducting socioeconomic research on Hyperloop revolved around gathering secondary data and further validating it through supporting statistics and the consensus gained from interviews. Despite the rather limited information sources due to the unexplored nature of Hyperloop, the research was facilitated by the results of recent Hyperloop implementation projects. The main quantitative sources used included performance metrics from existing Hyperloop projects and estimates of their socioeconomic impacts. Qualitative sources relied on interview insights from relevant stakeholders to capture public perception. Additionally, the team reviewed several case studies of the successful and failed Hyperloop implementations to identify unexplored socioeconomic factors that may impact its success.

Literature review was a primary contributor to this research paper. Discussions were formed to introduce members to different topics from literature and draw conclusions from group-based analysis. In general, topics are reviewed and discussed by members from all backgrounds, especially those in engineering, commerce, and health sciences. At the same time, short articles were drafted and prepared for publication as practices for the research paper, where members prepared topics for publishing on the team's website and beyond. Discussions outside of the team were also conducted with companies at conferences, other design teams, and university faculty members.

Results

Economic Accessibility

Hyperloop's economic accessibility requires us to evaluate various economic issues, such as fare pricing, infrastructure costs, societal impacts, and overall economic benefits. The Hyperloop is a high-speed mode of transportation, with initial estimates suggesting that a round trip between cities like Los Angeles and San Francisco could cost around $40. However, these estimates, based on Elon Musk's early projections, have been criticized as overly optimistic.

While Musk envisioned affordability, concerns have risen regarding the real-world implementation of Hyperloop and its economic accessibility. Critics argue that Musk's projections may have underestimated operational and construction costs and overestimated passenger numbers. These factors could result in significantly higher break-even fares, making ticket prices comparable to airfare rather than existing ground transportation. This would consequently limit Hyperloop's accessibility to higher-income individuals and families.

TABLE 2 | Capital costs of hyperloop in various corridors using different assumptions.

Location	Costs as per VHO (USD million per km)	Assuming Walker (2018) realistic findings based on 32.3% increase in the cost of VHO (USD million per km)	Assuming overrunning costs 50% increase in Walker's value (USD million per km)
Los Angeles - San Francisco	$75.6	$100	$150
Abu Dhabi – Dubai	$32.5	$43	$64.5
Helsinki - Stockholm	$40.0	$53	$79.5

Elaborated and extended by authors based on Flyvbjerg (2005), Arabian Business (2016), Upbin (2016), and Walker (2018).

Figure 2: An analysis of costs per kilometer, considering Rosaline Walker's findings on the markup percentage of operational and construction costs [11].

The affordability and accessibility of Hyperloop are crucial considerations when assessing its potential impact on society. An expensive, high-speed transportation system exclusively accessible to wealthier demographics could exacerbate societal inequalities. Furthermore, the introduction of a Hyperloop system may attract retail activity, subsequently leading to an increase in property values and rental prices in areas surrounding the stations. This could potentially trigger gentrification, like the experiences of neighborhoods such as King's Cross in London after the implementation of High-Speed Rail stations [11].

Beyond gentrification, there's also the concern that Hyperloop could result in the displacement of residential communities, as observed with other large-scale infrastructure projects. Even residents far away from a Hyperloop station may bear some of the costs through taxes, despite not having easy access to its services. This raises questions about the fairness of such an arrangement, where a significant proportion of the population may end up subsidizing a service they cannot readily access or afford.

While Hyperloop presents concerns regarding economic equity, it also provides economic benefits to society. According to a study conducted by the U.S. Department of Transportation

and a 2019 Benefit-Cost Analysis, the Hyperloop could generate $19.1 billion in current-year dollars at a 3% discount rate, with wider economic benefits projected to be as much as $300 billion [12]. These benefits extend to the overall economy, beyond simply the passengers using the service. One key economic advantage of the Hyperloop system is its potential use for freight transport, particularly for time-sensitive goods. This could greatly increase freight capacity and efficiency, offering an attractive alternative to traditional road freight and potentially stimulating economic growth [12]. The increased revenue generated from this aspect could help offset the high operational and construction costs of the Hyperloop system, subsequently leading to potentially more affordable passenger fares in the long run.

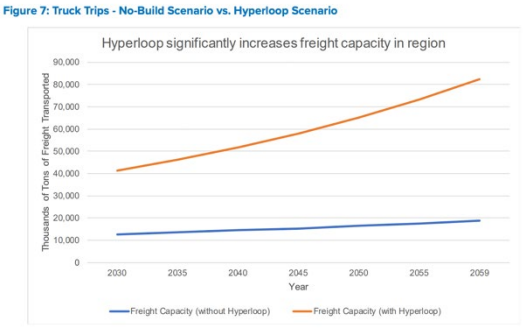

Figure 3: illustrates how Hyperloop can greatly increase freight capacity, especially for time-sensitive resources, thereby boosting economic growth and potentially leading to more affordable Hyperloop tickets due to the generated revenue's postive impact on other aspects of the economy [12].

Policymakers, governments, technology professionals, and transportation experts have a crucial role to play in ensuring the Hyperloop is accessible to a variety of socioeconomic groups. As they guide the development and implementation of the Hyperloop, continuous reassessment of the project's economic implications is vital. Open dialogue and transparent decision-making must also be fostered to consider all potential effects on society. By working proactively, these stakeholders can ensure that the Hyperloop does not exacerbate the economic divide but instead serves as a means of improving connectivity and accessibility for everyone.

Moreover, governments have the power to implement regulations and policies that can promote more equitable access. This might include subsidies for lower-income riders, zoning policies to prevent gentrification around Hyperloop stations, and inclusive urban planning strategies to ensure Hyperloop stations are accessible to diverse neighborhoods.

Ultimately, we believe that all stakeholders involved in this process must ensure that these considerations of economic accessibility are not an afterthought but are embedded in the development of Hyperloop's implementation. We must work together to create a transportation revolution that benefits everyone, not just a select few.

Redefining Urban Development

Said to be safer than cars, faster than trains, and far less damaging to the environment than aircraft, the Hyperloop has the potential to completely reinvent urban development. The closest comparison of transportation to Hyperloop is well known to be high-speed rail (HSR), which is predominantly found in Western Europe and Asia. We can look to Japan, where for 20 years, the cities of Tokyo and Osaka had the only HSR system. It is considered the most successful HSR system in the world, with 300 million customers being served in 2012 [13].

What contributed to its success? Location, speed, and safety. The location of the initial HSR system connects Tokyo to Osaka, two cities approximately 400 kilometers apart, representing an ideal location for an HSR system that connects cities within a range of 450 to 700 kilometers [13]. The speed of HSR was revolutionary when it was first implemented, providing commuters with significantly faster travel times and cheaper tickets compared to air travel. With continuous improvements, HSR lives up to its name. Furthermore, the safety record of HSR is incredible, with zero fatalities or injuries throughout the system's existence, which covers four different lines with a total operating distance of 2,388 kilometers [13].

So how does this connect to Hyperloop? Hyperloop promises to meet and exceed these three criteria, along with other advantages. The following chart illustrates the time saved through Hyperloop travel compared to HSR from London to major cities in the UK.

Table 1: Hyperloop travel time (minutes) VS HSR travel time (minutes) from London, United Kingdom to other major cities in the United Kingdom [14].

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

The difference in speed between Hyperloop is compared to HSR is remarkable, as it significantly reduces commute times and expands the livable areas within the UK. This impact extends around the world. As mentioned previously, the Japanese HSR connected the cities of Tokyo and Osaka, which are approximately 400 kilometers apart, making commuting much easier for residents. Additionally, most of the Japanese cities are coastal – they span the coast of Honshu Island, the largest of the Japanese islands [13]. HSR's vast network has enabled these coastal cities to connect seamlessly, creating flexibility for residents. With Hyperloop, people would have the ability to live even further apart, or in the case of Japan, travel across the country in the time it takes for an extended car ride.

Aside from travel time reduction, Hyperloop would also affect many other aspects of life. Higher education is a big factor in most people's lives. Higher education plays a significant role in people's lives, but its high costs often cause individuals to remain close to home, saving valuable sums of money while pursuing academic achievements. Hyperloop would allow longer distances to be travelled much more quickly, providing students with greater flexibility when choosing higher education. This could subsequently result in more people opting for higher education, as the cost-of-living would be lowered for students who can now live at home.

For elementary education, Hyperloop would allow parents to consider a wider range of schooling to fit their child's needs and eliminates school zones. This increased mobility can result in a more diverse and well-rounded educational background, as students can easily participate in exchange programs, attend conferences, and engage in collaborative projects with other institutions. The Hyperloop has the capability to bridge the gap between urban and rural education by providing equal opportunities stemming from increased mobility.

A Hyperloop network has the capability to create an affordable and convenient support system that would benefit regular workers. The financial instability arising from sky-high living expenses in prominent urban centers, such as London and San Francisco, is forcing many residents to relocate. San Francisco, for example, has only added 1,500 net new housing units per year, with that metric hitting an all-time low of 269 in 2011. In 2012, 40,000 new jobs were added, creating an extreme imbalance in supply and demand [15]. By reducing travel time and costs, Hyperloop can enable people to live farther away from expensive urban centers while still

being able to commute to work efficiently. This could lead to a more even distribution of the population and alleviate the pressure on housing in densely populated cities [14]. In addition to providing reduced transportation times, Hyperloop systems could also help reduce traffic congestion on roads, rails, and in the air, as they may capture a significant share of the transport market. This could lead to a more sustainable and efficient transportation system, indirectly contributing to addressing the housing crisis by making it more feasible for people to live further away from city centers.

Lastly, Hyperloop has the capability of redefining medium-distance travel typically taken by air. If every passenger trip between 500km and 1,500km that is currently made on flights were done through Hyperloop instead, emissions could be reduced yearly by 58% [14], thus promoting sustainable travel to passengers. The Hyperloop passenger experience is designed to be more convenient and comfortable than air travel. An ideal Hyperloop system would allow local boarding, reducing travel time relative to air travel by eliminating or greatly reducing the time spent at either end of the journey. Additionally, the boarding process could be as simple as scanning a ticket and walking to the correct departure track, like train stations or high-speed rail stations [16]. Furthermore, while the exact costs of Hyperloop travel are still uncertain, some estimates suggest that it could be more affordable than air travel. For example, a feasibility study by Hyperloop One estimated that the cost per seat-kilometer for Hyperloop would be around $0.008, compared to $0.031 for high-speed rail and $0.034 for air passenger transport. If these estimates hold true, Hyperloop could offer a more cost-effective alternative to air travel for medium-distance trips [17].

Hyperloop For E-Commerce

With the E-commerce market projected to exceed 8.2 trillion US dollars by 2026, the need for efficient and sustainable forms of transportation has become increasingly important to meet the growing demands of consumers [18]. By transitioning from traditional forms of transportation to hyperloop systems, the industry can achieve a reduced carbon footprint, faster delivery times, and decreased road congestion.

The shift from trucks to hyperloop systems offers solutions for the trucking industry's current issues with driver shortages, retention rates, and the growing demand for high-speed delivery services. As the trucking industry is the current primary form of transportation to move freight in

North America, transitioning to a hyperloop system would alleviate the burdens faced by the trucking industry [19].

Furthermore, the current use of the trucking industry has detrimental effects on the environment. Transport, having the highest reliance on fossil fuels, is currently the largest source of carbon dioxide emissions worldwide, accounting for nearly 40% of all carbon dioxide emissions in 2021 [20]. Road freight alone was responsible for releasing over 2.2 billion tons of carbon dioxide in 2020, the largest contribution of any type of freight transport [21]. Implementing a hyperloop system as an alternative to freight trucks for package delivery would significantly reduce carbon emissions and air pollution. This transition would contribute to a greener and more sustainable future for the e-commerce industry, aligning with global efforts to combat climate change.

Studies show that at least 66% of US consumers consider sustainability a major factor when making purchases [22]. Using hyperloop as a preferred method of shipping goods would allow businesses to boast the use of a zero-emission transportation mode to their customers. This would enhance the brand's image as responsible and eco-friendly and attract a growing segment of environmentally conscious consumers.

Additionally, hyperloop offers another compelling advantage for e-commerce: faster delivery times. A study conducted by UPS revealed that most people consider delivery speed as a crucial factor when searching for and selecting products to buy online [23]. To meet the demand for swift delivery, prominent e-commerce giants like Amazon need innovative transportation solutions. For example, with travel speeds over 1000km/hour, the Canadian company TransPod's system implemented between Montreal, Ottawa, and Toronto is estimated to save both businesses and consumers 2.15 million hours of freight transport time per year [8]. Implementing the hyperloop system can revolutionize the industry by providing rapid transport, enabling e-commerce companies to satisfy the growing demand for prompt and efficient shipping services.

Finally, statistics provided by the World Economic Forum on road congestion caused by e-commerce provide another case for the implementation of the hyperloop system. Not only is there projected to be a 36% increase in delivery vehicles in cities by 2030, but congestion levels are also estimated to rise by 21%. This translates to an additional 11 minutes of commute time per person on a daily basis [24]. This congestion will cause inefficient deliveries and negatively impact urban residents' and commuters' quality of life. With the implementation of the

hyperloop system, this issue can be addressed, as businesses using hyperloop for cargo transport would reduce the need for trucks. This change would not only enhance the productivity and well-being of individuals but also improve overall traffic flow and enable smoother and more effective e-commerce operations.

To conclude, as the e-commerce industry continues to expand rapidly, innovative solutions are needed to satisfy both businesses and consumers. Transitioning from a heavy reliance on the trucking industry to a hyperloop system would address key challenges and meet evolving demands. The advantages of adopting a hyperloop system for e-commerce include a reduced carbon footprint, fast delivery times, decreased road congestion, and better service for businesses' e-commerce activities. The hyperloop system is a solution that would pave a more efficient and sustainable future for the e-commerce industry.

Usage of Hyperloop in Ports

The marine port industry plays a crucial role in global trade and supply chain management, with an evaluation of $148.1 billion market size in 2020 [25]. However, it has come to light that most ports face similar challenges in the last decade, including lack of effective strategies, inadequate investments, and numerous negative environmental impacts [26]. Using Hyperloop technology, cargo transport in ports can be revolutionized to improve supply chain logistics, reduce costs, and increase sustainability.

In July 2021, Hyperloop Transport Technologies announced their hyperloop integrated solutions for port revolution—Hyperport. To be first implemented in Hamburg, Germany, Hyperport features Mag-lev rails to eliminate rolling resistance and fires cargo at a top airplane speed of 600 km/h [27]. The system is designed to move 2,800 twenty-foot equivalent units (TEU) a day, which is much more comparable to the average of 64 TEUs transported each train service from British ports [28]. With its enclosed operating environment, Hyperport aims to eliminate at-grade crossings to increase reliability, efficiency, and worker safety [29].

Hyperloop technology offers high-speed, low-pressure environments for cargo movement, revolutionizing supply chain logistics in ports. Firstly, Hyperport boasts top speeds of 600 km/h, which is fifteen times faster than the traditional freight train speed of 40 km/h. Reduced transit times not only improve supply chain efficiency, but also facilitates faster inventory turnover and addresses other common challenges that ports currently face. From a logistics perspective,

Hyperport reduces congestion and increases operational efficiency by autonomously loading and unloading TEUs. Specialized capsules then connect seaports to in-land ports, which allows for operations to be conducted from the hinterlands, thus increasing capacity, and returning high-value coastal real estate in the quayside to surrounding communities [29].

Hyperport also seeks to significantly reduce logistics and operations costs. Due to the nature of the technology using linear motor Maglev and low-pressure tubes, Hyperport can greatly reduce drag and rely on a relatively small amount of electricity to propel cargo pods at airplane speeds [30]. This creates a much more cost-effective system compared to high-speed rail or airline transportation, in addition to eliminating the cost of burning fossil fuels and carbon dioxide emissions that alternative transport methods face. Furthermore, it is possible that Hyperport may generate more energy per year than it consumes, as solar panels or other renewable energy sources may be installed for energy production [31].

Lastly, Hyperloop offers notable sustainability advantages over conventional transportation modes within ports. Hyperloop Transport Technologies analysts estimate that if implemented worldwide, Hyperport will reduce carbon dioxide emissions by 143 million tons per year, which would decrease the emissions of the entire shipping industry by 15% alone [31]. The energy efficiency of Hyperloop systems consumes significantly less power per unit of cargo transported compared to trucks and freight trains. Furthermore, Hyperport will also allow the shipping industry to move cargo in a closed operating environment, eliminating the traffic or environmental impacts that traditional trucks and freight rails currently impose.

Integrating Hyperloop technology in ports has the potential to revolutionize supply chain logistics, reduce costs, and improve sustainability. By significantly reducing transit times, increasing capacity, and offering a sustainable alternative to conventional modes, Hyperloop systems like Hyperport pave the way for efficient, cost-effective, and eco-friendly port operations. In addition to Hyperport being built in Hamburg, Germany, this port hyperloop technology can potentially find great success in Rotterdam, Netherlands, which is Europe’s largest port and vital hub for international trades. Another example could be in Singapore, which is one of the world’s busiest transshipment hubs and serves as a gateway to Southeast Asia. Due to the density of the city, Hyperloop would be able to maximize its efficiency as it phases out alternative transportation that causes further congestion within the city.

Application of Replacing Trucks

The transportation sector, particularly the use of trucks for cargo transport, presents challenges related to transit time, road safety, and emissions. Hyperloop technology, with its potential for high-speed, efficient, and sustainable transportation, offers a promising alternative to traditional trucking. The first prominent benefit of the Hyperloop system is the improvement in transit speed of cargo. Hyperloop can travel over 600 km/h, which is over 7 times faster than the speed of trucks on interstate highways at 85 km/h [32]. Furthermore, the traditional trucking industry faces challenges related to congestion, limited road capacity, and variable traffic conditions, resulting in longer transit times for goods transportation. These considerations are eliminated with the Hyperloop system, which can drastically reduce delivery times. A study conducted by Virgin Hyperloop estimated that a hyperloop journey between Los Angeles and Las Vegas, a route that typically takes about four hours by truck, could be completed in just 30 minutes, increasing transit speed efficiency by 700% [33]. The substantial reduction in transit time provides enhanced efficiency and responsiveness in supply chains, benefiting businesses and consumers alike.

Road safety and congestion can also be improved by utilizing Hyperloop technology in an attempt to phase out trucks as cargo transit modes. According to the Texas Transportation Institute, highway congestion costs 8.7 billion hours of wasted time and 3.5 billion gallons of wasted fuel, adding up to a wasted $190 billion in 2019 [34]. Lost productivity, cargo delays, and other costs add to additional tens of billions wasted through traffic congestion. As a result, there is a large opportunity to reduce risk in wasted resources by replacing trucks for Hyperloop pods as a form of cargo transport. Furthermore, by eliminating trucks from large highways, road safety can also be vastly improved. In the last 10 years, there has been a 49% increase of large trucks being involved in a fatal crash [2]. By removing trucks off the roads and autonomizing cargo operations, Hyperloop can effectively mitigate human error within traffic, which is one of the leading causes of accidents. Based on a study conducted by the Insurance Institute for Highway Safety, 72% of crashes in the United States are avoidable and 90% of traffic accidents are caused by human error [35]. Due to the heavier nature of trucks, avoiding accidents with trucks can significantly reduce the fatality of traffic incidents with Hyperloop replacing trucks. This is especially important as road traffic crashes are the leading cause of death in the United

States for people ages 1 to 54 and are the leading cause of non-natural death for U.S. citizens [36].

Lastly, Hyperloop can greatly reduce greenhouse gases (GHG) emissions from trucks worldwide. In Europe, trucks account for 22% of road transport emissions, while making up only 2% of all vehicles on the road [37]. In the U.S., heavy-duty trucks only account for 1% of vehicles on the road, but account for 28% of on-road vehicle energy consumption and 47% of on-road vehicle nitrogen oxide emissions [38]. The environmental cost of trucks is high, as they emit 6 million tons of carbon dioxide per year in America alone [39]. Heavy-duty diesel trucks emit a variety of GHGs, which not only contribute to climate change, but also smog, acid rain, and irritants for local communities. Studies have found that if long-haul trucks were replaced by an electric alternative, such as Hyperloop, the economic value of climate and health damages are reduced by 80%, resulting in a net $5 billion annually in avoided costs [38]. This shift will also directly save thousands of lives, as local air pollutant emissions from interregional diesel trucks lead to more than 3000 lives lost annually in the U.S. [38]. By replacing trucks with Hyperloop technology, emissions from the trucking industry can be substantially reduced, contributing to global efforts to combat climate change, reducing costs, and improving health outcomes.

Table 2: Comparison of Hyperloop and Trucks for Freight Transport

Hyperloop	Trucks
• Average speed of 970km/h • Autonomized process creates safer operations and roads • Zero direct emissions • Carries less cargo, but faster transport • Technology must be built/implemented	• Average speed of 85km/h • Average of 433 people are injured and 14 people are killed in the U.S. in trucking accidents every day • Account for 20%+ of on-road emissions • Carries more cargo, but slow transport • Truck transport system already exists

The utilization of hyperloop technology to replace trucks presents significant advantages in terms of road safety, transit time reduction, and emissions reduction. By minimizing human error, enhancing efficiency, and offering electric-powered operations, hyperloop systems offer a safer, faster, and more sustainable alternative to traditional trucking. Embracing this innovative technology has the potential to revolutionize the transportation sector, ensuring safer roads, shorter transit times, and a cleaner environment.

A Comparative Analysis of Hyperloop Systems in Turkey and Canada

When bringing in a revolutionary form of transportation, it's critical to consider the challenges and opportunities hyperloop offers in different parts of the world. When comparing other hyperloop systems, there are several factors to consider, including geographic, economic, and government interests. To highlight the key differences, we will compare the hyperloop systems in Turkey and Canada.

Geographic factors play a significant role in the design and costs of the hyperloop system and route. In the case of Turkey, geography presents its own set of unique opportunities and risks. As Turkey is a transcontinental country covering an area of 783,562 km², spanning from Asia to Europe, it presents an opportunity to create a high-speed transportation system between the two continents. However, some significant challenges are that Turkey is placed in a seismically active region, with 20,277 earthquake tremors in 2021, leaving the hyperloop system prone to damage [40]. It presents a challenge for constructing hyperloop systems to withstand seismic forces.

Alternatively, Canada, with an area of 9.985 million km², face the benefit of having vast distances between cities and regions, creating an opportunity for fast transportation between major cities, including Toronto, Vancouver, and Calgary. With Canada and its diverse geographical features, they have the challenge of finding land as they must address geographical features like mountains, forests, and bodies of water. Additionally, with Canada's 2 billion trees commitment and its focus on forestry, finding land could be an issue for the hyperloop systems. In summary, Turkey and Canada exhibit specific geographic features that influence the costs and design of the system.

Economic factors and the amount of government interest significantly influence the development of hyperloop systems. In Turkey, the government has shown interest in investing in transportation to enhance connectivity with their recent investments in air and high-rail transportation as connecting cities could increase trade and tourism. One notable project in Turkey was the New Istanbul Airport which enhance connectivity between Asia and Europe. The head of Istanbul Grand Airport says this airport will “be the most important hub between Asia and Europe” as they are planning to create more airports in the future [41]. These recent investments show government interest in enhancing connectivity among the two continents with

high-speed transportation. However, another key statistic is Turkey's increasing interest in developing nuclear plants and healthcare systems. For reference, the Akkuyu Nuclear power plant is predicted to cost $20 billion USD, whereas the development of the third Istanbul Airport is expected to cost at around $6.3 billion USD, placing the infrastructure of the airport as the 5th most amount of money spent on infrastructure [42].

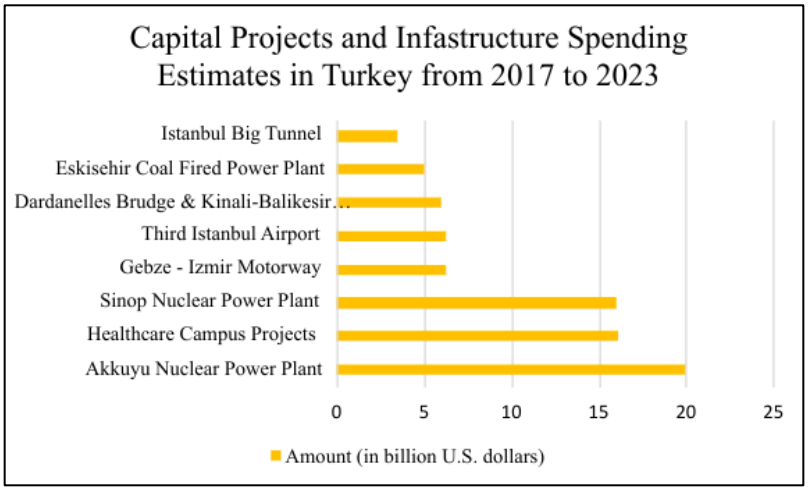

Figure 4: Capital Projects and Infrastructure Spending Estimates in Turkey from 2017 to 2023

This suggests that Turkey's infrastructure industry may focus more on different capital projects, such as nuclear plants and healthcare. In Canada, the government is investing $14.9 billion in fast, affordable, cleaner transit solutions over the next eight years [43]. Annually, the government expenditure on current transportation is expected to increase from $554 million in 2023 to a projected $578 million in 2026, increasing the 1.2% of government funding to 1.63% [44]. This investment growth could indicate a greater focus on public transportation and innovation potential.

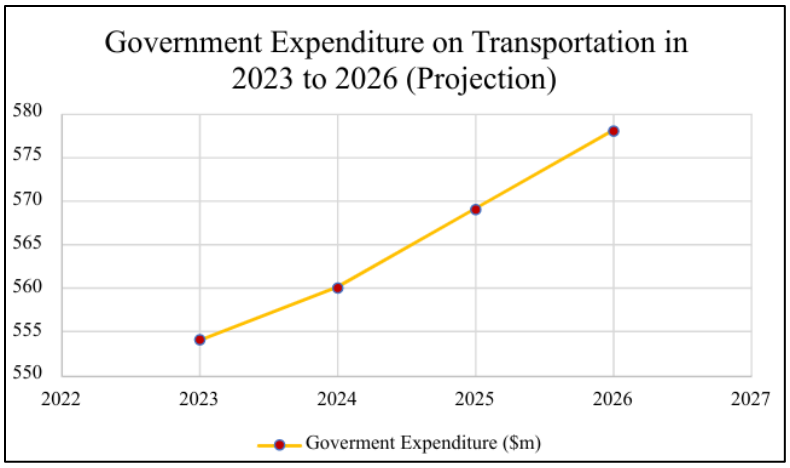

Figure 5: Government Expenditure on Transportation in Canada from 2023 to 2026 (Projection)

Table 3: Expected Government Expenditure and Investment with corresponding percentage change from 2023 to 2026

Year	Government Expenditure and Investment ($m)	Annual Change in Expenditure and Investment (%)
2023	554	1.22
2024	560	1.14
2025	569	1.47
2026	578	1.63

In conclusion, Turkey and Canada have great potential to bring hyperloop technology with their own challenges and benefits. Turkey has shown great interest in innovating transportation technology and connectivity between Asia and Europe. Canada hopes to improve connectivity among the vast distances between provinces. By understanding the critical geographical and economic factors, the hyperloop can be a revolutionary form of transportation that is safe and efficient.

Physical Accessibility

In recent years, hyperloop technology has generated anticipation and excitement as a revolutionary mode of transportation that promises new levels of speed and efficiency. However, as we embrace the potential of hyperloop systems, it is crucial to consider the physical accessibility issues that may affect people with mobility impairments, heart conditions, or other medical conditions that may make traveling difficult. This portion of the paper will focus on the implications of making hyperloop accessible, by examining how previous models attempted to be physically inclusive and discussing potential solutions. Addressing these accessibility challenges will be crucial to ensuring that the benefits of hyperloop technology are accessible and inclusive for everyone.

While the development of hyperloop technology is in its early stages, the consideration of physical accessibility has been recognized as an essential aspect to focus on previous models of hyperloop. Specifically, in TransPod, a Canadian transportation system, their design was made to be accessible for all individuals with mobile disabilities in mind, from spacious interior to wide doors on both ends [8].

To ensure accessibility, laws, regulations, and efforts are in place. Existing efforts, such as the Accessible Canada Act (ACA), aim to create a barrier-free environment for individuals with disabilities. The ACA establishes a framework for businesses, buildings, and transportation to promote accessibility for individuals with disabilities [45]. Additionally, laws in the human rights code require all forms of transportation to provide accommodations for all individuals and prohibit discrimination in services [46]. These guidelines extend to requiring accessible stops, stations, and staff with proper training. While hyperloop technology is a relatively new form of transportation, it is expected to adhere to existing accessibility standards to ensure accessibility in all forms of transportation, including emerging ones.

When designing a hyperloop system that is inclusive of all passengers, companies should consider spacious interiors with sufficient space to accommodate individuals with mobility aids such as wheelchairs or crutches. Incorporating accessibility features like ramps, lifts, and adjustable seating is a solution.

By ensuring that hyperloop technology follows laws and regulations and incorporates physical accessibility in future designs, hyperloop can be accessible for all groups. With these efforts, hyperloop technology can truly revolutionize transportation by making it accessible for everyone.

Environmental Impacts of Hyperloop

One of the key benefits for Hyperloop is the energy efficiency it demonstrates when compared to other transportation methods such as cars, airplanes, as well as the traditional train. A major reason for this is due to its magnetic levitation or “maglev” design which allows for negligible air resistance and nearly no friction at all [47]. Musk’s initial proposal for Hyperloop described that solar panels atop the tube would provide propelling energy, and that storing that energy would also be possible in the face of non-sunny conditions, with it also being speculated that sunny locations such as Las Vegas or the Bay Area would generate more energy than needed on

most occasions [47] [11]. However not every country in the world can sustain Hyperloop off of solar energy alone due to differing altitudes or climates, so it would make sense to look into other renewable energy sources as well [11]. Considering that Hyperloop would ideally use clean renewable energy sources then greenhouse gasses should have minimal emissions during the operational phase, however it is almost inevitable that these emissions would be very high during the construction of infrastructure, and this is not considering the loss of trees and other ecological systems [47].

Regarding the land usage of Hyperloop, according to an HSR analysis done in China during 2019 it was found that in cities which accommodate HSR infrastructure that land is natural land is drastically reduced which from another report more than likely stems from land clearing, tunneling, or in some cases even the demolition of historical buildings [48] [49]. As Hyperloop would require these same steps to build its infrastructure, cities that implement the system would be likely to experience the same effects while also harming surrounding agriculture and wildlife that may be situated between two Hyperloop connected cities [49]. Due to the lasting effects of these issues, it is paramount that Hyperloop systems be proposed between cities where such damages can be minimized, and wildlife can be preserved.

Hyperloop may not only have the effect of destroying wildlife and land during the infrastructure phase, but it can also affect human and animal communities during the operational phase as well. The vacuum pumps from Hyperloop systems are theorized to create noise, and the magnitude of the resulting noise pollution could have unforeseen yet crucial effects [48]. For example, the noise could disturb local wildlife which in the absolute worst-case scenario would lead to behavioral changes and possible relocation, and the noise could also be a deterrent for humans as well if loud enough. One idea to negate these effects is possible insulation which could hopefully minimize any negative impacts of the noise.

In addition to the audible effects of Hyperloop, the visual should be assessed as well. As a key part of Hyperloop infrastructure are the elevated corridor pillars, these structures may create visual eyesores for nearby residents and create a sort of barrier effect on nearby neighborhoods [49]. These pillars may not only be an unwelcome sight for residents but may also impose restrictions on the use of public space, which ultimately may lead to opportunity costs as

civilians may even choose to move away from these areas which makes it crucial that terminals are integrated well with already existing public transport [48].

While Hyperloop carries the potential for a greener and more efficient mode of transport, it is important to recognize and address its environmental impacts. Processes should be carefully planned to mitigate any damages during the development stages of Hyperloop infrastructure as well as during the operational phase as well. Planning from experts in the environmental and political fields should be consulted to ensure the proposed system is sustainable, minimizes the environmental footprint as well as to make sure that wildlife, agriculture, and nearby neighborhoods are not disturbed by the construction and operation of the Hyperloop system. By considering the consequences of the Hyperloop system from an environmental perspective, we can strive towards a future where innovation and sustainability go hand in hand.

Redefinition of Global and Domestic Interconnectivity

To analyze the potential impact of a hypothetical hyperloop connecting Toronto and Montreal, which currently do not have developed hyperloops, we can consider several key factors. These cities are ideal for this study as they meet the optimal criteria outlined earlier. By car, Toronto and Montreal are approximately 542 km apart, by plane 503 km, and by train 541 km [50]. Toronto has a population of just over three million people, while Montreal has a population just above two million [51]. These cities serve as economic hubs, with Toronto generating a GDP of 270 billion and Montreal 148 billion [52]. The population density is 4,457 people per square kilometer for Toronto and 4,916 people per square kilometer for Montreal [53]. Moreover, approximately 40 million people travel between these cities each year by various means of transportation, including cars, buses, planes, or trains.

The connection between Toronto and Montreal through a hyperloop will have significant impacts in two major areas. Firstly, travelers between the cities will benefit from a fast, convenient, and affordable mode of transportation. For leisure purposes, hyperloops will offer a quicker and more convenient alternative to traditional transportation methods. Unlike air travel, hyperloops will not require early arrivals and will be more cost-effective. Additionally, hyperloops will outperform driving or taking a train in terms of speed. For frequent commuters, this connection will save hours of commuting time. Moreover, due to the ability to arrive at the station, purchase

a ticket, and depart from the city within a short timeframe, many of these commuters will avoid the need for overnight stays, resulting in substantial time and cost savings.

Secondly, from a freight and shipment perspective, as two of Canada's major importers, this hyperloop connection will alleviate daily congestion and provide a new and efficient pathway for imports and exports. This development will significantly reduce shipping time and costs while enhancing logistical efficiency and creating new opportunities. The addition of an efficient mode of freight transportation will unlock new possibilities for Canadian businesses, enabling them to effectively utilize the resources and population of the connected cities for development and growth.

In summary, a hyperloop connection between Toronto and Montreal has the potential to revolutionize travel for both leisure and business purposes, providing a quick, convenient, and cost-effective option. Furthermore, it will streamline freight transportation, reducing congestion and enhancing efficiency, leading to improved economic prospects for businesses in both cities.

Population Density and High-Speed Transportation

Population density is a crucial metric when assessing the potential success of a hyperloop system, often serving as a decisive factor in determining the validity of high-speed transportation projects. Examining the use of High-Speed Rail (HSR) worldwide reveals a clear pattern. Asian countries with high population densities, such as China, leading the world with 37,900 km of HSR track, and Japan with 30,000 km of track, have been at the forefront of HSR success [54] [13]. In contrast, Western countries with lower population densities, like the United States, have lagged in HSR development.

Despite the United States boasting a land mass 2,500% larger than Japan's, Japan has achieved far greater success in HSR technology and usage. While high-speed transportation can cover long distances in short periods, it becomes inefficient for extensive travel due to its high development costs. Developing a kilometer of HSR track costs anywhere from 10 to 25 million euros, while a kilometer of hyperloop track costs around 45 million euros [55] [11]. Consequently, high-speed transportation becomes disproportionately expensive compared to alternative modes that offer similar travel times, such as air travel and cargo.

This puts high-speed transportation in a unique space. While other fast transportation modes excel in long-distance travel, hyperloops find early-stage success in distances ranging from 200 to 1,000 kilometers. Within this range, projects become financially viable, and competing modes of transport notably lag behind hyperloops in terms of speed. However, given the high costs associated with covering manageable distances, Western countries like the United States often lack the population density required to make these projects economically justifiable. Asian countries with population densities exceeding ten times those of their Western counterparts have the capacity to support such endeavors, resulting in noticeably higher investments in high-speed transportation.

Nevertheless, this does not imply that HSR and hyperloops are not viable in the Western hemisphere. As cities like Dallas continue to experience unprecedented growth rates, these projects become increasingly viable. Population growth rates are not the sole factor making these projects feasible in the Western world. The development of these projects will induce an increase in the population densities of the connected cities. A hyperloop connecting two cities effectively merges them into one in many aspects. This integration leads to enhanced job opportunities, GDP, foreign investment, city development, access to education, social connections, and amenities for both leisure and daily life. These drastic improvements attract economic growth and development, further compounding factors that entice immigration. As this cycle continues, the viability of these projects will progressively increase as more people choose to move into the connected cities.

While population density remains a crucial consideration when forecasting the success of high-speed transportation projects, these projects themselves will stimulate population growth, enhancing their viability over time.

Discussion

Hyperloop is a complex system with complicated problems that can span many industries. From the research conducted, it is evident that there are benefits in both cargo and human transit, but also problems related to infrastructure and finances. In general, the most significant socio-economic challenges relate back to the technical problems being solved today, which is to say that the current level of technology may not guarantee an affordable and realistic system. To start, the question of how to effectively build a long vacuum channel must be answered due to it

being the most challenging obstacle in the way of many Hyperloop projects. Beyond that, government and private companies will continue to influence the trajectory and speed of Hyperloop projects like TransPod, especially when a commercial Hyperloop system has yet to be realized.

Other than the technical aspects of the Hyperloop, immediate feasibility depends on various broader implications such as economic accessibility, physical accessibility, environmental effects, and more. Economic accessibility is a considerable issue, particularly as the wealth gap continues to widen. Potential solutions include seeking government funding, investment capital, and R&D to drive innovation and cost reduction for hyperloop technology.

Moving onto the topic of physical accessibility in future hyperloop designs, it is not likely that future designs will not be inclusive. This is primarily due to the laws, policies, and regulations that require all forms of transportation to be inclusive. Moreover, previous hyperloop models have made efforts to be inclusive and accessible, following universal design principles like wheelchair-friendly pathways.

When considering the environmental impacts of hyperloop systems, it's critical to compare their long-term effects to other forms of transportation like sky trains and buses. While Hyperloop may have some initial negative impacts on wildlife and agriculture, it would be more environmentally friendly in the long run due to its reduced emissions and energy consumption.

While there are arguments suggesting that the hyperloop could replace trucks, it is crucial to acknowledge that these two modes of transportation have distinct qualities, making a redirect replacement unlikely. Just as paper is not an exact substitute for plastic, the hyperloop is not a complete replacement for trucks. Hyperloop's flexibility reaches a limit in accessing underdeveloped or remote areas. Rather than hyperloop replacing trucks, Hyperloop and Trucks can collaborate for efficient and timely delivery of products. Hyperloop can transport goods to central cities, while trucks can handle the last-mile delivery to households or businesses located far away from the hyperloop stations.

Hyperloop presents both challenges and opportunities for the future of transportation. While technical feasibility and economic accessibility remain vital issues, the potential benefits of long-term environmental impact, and innovation in existing systems, are promising for the future.

Further, with continued research and development efforts, collaboration with governments, stakeholders, and private companies can help address the challenges of hyperloop and unlock the full potential of hyperloop technology. In the future, the team hopes to explore more into similar topics, especially in methods to increase economic value and viability for Hyperloop projects in the long term.

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