Review and Real World Usability of Magnetic Levitation Trains

Submitted in partial fulfillment of the requirements
Of the degree of
BACHELOR OF TECHNOLOGY
IN
MECHANICAL ENGINEERING

By

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by Anshuman Srivastava and Anurag Chaturvedi, is approved for the degree of bachelor of technology in mechanical engineering.

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ACKNOWLEDGEMENT

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ABSTRACT

Hyperloop technology companies have taken two main approaches to testing. A number of privately funded companies, including TransPod, Hardt, and Zeleros, have proposed, or have approval, to develop small scale test facilities (i.e. 1 to 3 km in length with a scaled down tube and vehicle) at various sites in Europe. Their key purpose is to identify design issues and potential ways to reduce the overall capital and operational costs for a full-scale Hyperloop. In the future, these facilities may be extended and enlarged for full-scale testing or commercial use. The other approach, taken by companies such as Virgin Hyperloop One, is to develop a full-scale test facility (i.e. full-scale tube and vehicle) to conduct testing of their concepts. Current test facilities used by the leading technology developers have been sufficient to prove the concept of levitation for the various pod designs and, in some cases, to prove low-level speeds (relative to the projected top speed). As indicated during conversations with several of the

companies, the next step is to secure the use of, or develop their own, testing facilities where pods can be tested at higher speeds.

As interest and support for Hyperloop increased, a number of companies began to consider possible routes and locations for application of the technology. An example of this occurred in May 2016, when the Hyperloop One Global Challenge was launched to find potentially viable locations for Hyperloop networks. The challenge saw a number of different feasibility studies submitted from locations around the world, assessing the viability of Hyperloop as a mode in various corridors. These studies built on Musk's original premise that Hyperloop could be a viable alternative to ground-based high-speed transportation. As analysis of these routes was undertaken, many of the studies found that not only would Hyperloop compete with high-speed rail, but that theoretically, it was also positioned to challenge short-haul and, in some cases, medium-haul airline routes. Although these studies were based solely on the theoretical capabilities of Hyperloop, the findings and potential benefits of such a system have resulted in further interest and investment in this technology.

1. Introduction

Hyperloop is a potential new form of high-speed transportation for the movement of passengers and freight over long distances. The key component of the Hyperloop concept is the use of low-pressure tubes to move vehicles (pods) at speeds rivalling air travel. The adaptation of a low-pressure environment within the tubes minimizes aerodynamic drag (see Figure 1), allowing vehicles (pods) to reach and maintain higher speeds than existing ground-based modes of transportation while using less energy. Like railways, Hyperloop vehicles would operate within a fixed guideway environment but without the wheels that generate significant rolling friction at high speeds. Instead, the vehicles would use magnetic levitation (MagLev) along with electromagnetic (and/or

aerodynamic) propulsion to glide along a fixed guideway, similar to existing MagLev technologies. One key conclusion, based on the evidence gathered, is that Hyperloop as a mode has not yet been fully conceptualized. Many of the questions investigated could not be answered because the technology is not sufficiently mature, has insufficient information/design options, or in some cases, an absence of initial ideas. With so many unknown aspects remaining, it is difficult to determine if Hyperloop will become a viable mode of transportation. Based on this assessment, several technical components are in the very early stages of development and likely years away from functional realization.
Although uncertainty remains over Hyperloop's viability based on the current level of development (as of March 2020), this appraisal recognizes that the swift evolution of the concept from 2013 to date gives cause for optimism. The rapid rate of technological development and refinement over this time period reflects how challenges considered insurmountable only a few years ago have been overcome, offering a degree of reassurance that current issues might be similarly resolved. However, such infancy in the development of several key components, such as high-speed switching and communications, leads to the conclusion that Hyperloop, in its current state, is unlikely to be ready for real- world application in the near future. Given the length of routes being considered, the phases of environmental assessment and planning, through to design and construction of transportation infrastructure at such scale, these will likely take many years to complete. In consideration, it is highly improbable that Canada can expect to see a viable commercial route until well into the next decade and, given the number of current uncertainties, this could still be claimed to be an ambitious timeline.

List of figures

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Introduction

1.1 Hyperloop technology is still in development even though the basic concept has been around for many years. At the moment, the earliest any Hyperloop is likely to be up and running is 2020 but most services are expected to be later, as trials of the technology are still in their early stages.The idea of using low-pressure or vacuum tubes as part of a transport system has a long heritage. The Crystal Palace pneumatic railway used air pressure to push a wagon uphill (and a vacuum to drag it back down) way back in Victorian south London in 1864. Similar systems using pneumatic tubes to send mail and packages between buildings have been in use since the late nineteenth century, and can still be seen in supermarkets and banks to move money around today.

One clear predecessor of the Hyperloop is the 'vactrain' concept developed by Robert Goddard early in the twentieth century; since then, many similar ideas have been proposed without much success. The basic idea of Hyperloop as envisioned by Musk is that the passenger pods or capsules travel through a tube, either above or below ground. To reduce friction, most -- but not all -- of the air is removed from the tubes by pumps. Overcoming air resistance is one of the biggest uses of energy in high speed travel. Airliners climb to high altitudes to travel through less dense air; in order to create a similar effect at ground level, Hyperloop encloses the capsules in a reduced-pressure tube, effectively allowing the trains to travel at airplane speeds while still on the ground.

The pod would get its initial velocity from an external linear electric motor, which would accelerate it to 'high subsonic velocity' and then give it a boost every 70 miles or so; in between, the pod would coast along in near vacuum. Each capsule could carry 28 passengers (other versions aim to carry up to 40) plus some luggage; another version of the pods could carry cargo and vehicles. Pods would depart every two minutes (or every 30 seconds at peak usage).

1.1.1 Objective of the project

A. Can the Hyperloop concept be transformed into a viable technology that is safe for passengers and the communities where the tubes traverse?
B. Is the Hyperloop technology cost significantly more affordable than, or at least comparable to, conventional High-Speed Rail systems or developing Maglev technologies?
C. To understand the various engineering concepts and designs, an independent review of the technology was conducted by AECOM, which included a series of technology readiness level assessments.
D. To inform the readiness of the technology for application in Canada, a hazard and risk assessment was also conducted, with the resultant risks compared to those extant in other transportation modes and a discussion provided examining how these had been mitigated.
E. Finally, to gain a more complete understanding of the technology, a high-level preliminary capital and operating cost analysis was performed, which included a comparison of Hyperloop technology as a new mode with other existing transportation modes.

1.2 Key Findings: One key conclusion, based on the evidence gathered, is that Hyperloop as a mode has not yet been fully conceptualized. Many of the questions investigated could not be answered because the technology is not sufficiently mature, has insufficient information/design options, or in some cases, an absence of initial ideas. With so many unknown aspects remaining, it is difficult to determine if Hyperloop will become a viable mode of transportation. Based on this assessment, several technical components are in the very early stages of development and likely years away from functional realization.

Although uncertainty remains over Hyperloop's viability based on the current level of development (as of March 2020), this appraisal recognizes that the swift evolution of the concept from 2013 to date gives cause for optimism. The rapid rate of technological development and refinement over this time period reflects how challenges considered insurmountable only a few years ago have been overcome, offering a degree of reassurance that current issues might be similarly resolved.

The level of uncertainty over the resolution of remaining challenges and timescales for the technology directly impacts the anticipated cost of the system. The study found that, when first conceived in 2013, the per kilometre system cost was estimated at $19M and is now forecast to be closer to $56M. Such a significant rise is largely due to the increased technical complexity of the system as the concept has been refined. This revised capital cost, by comparison, places the system higher in price than high-speed rail, and in some ways more comparable to MagLev technology. The study also considered how operational costs might compare with other modes, however, given the lack of known quantities and supporting infrastructure and operations, it is highly challenging at this stage of technological development to accurately quantify the operational costs of the system. Hyperloop as a new transportation concept, shows promise, however, too many uncertainties exist for it to be considered a near-term, viable alternative to present-day high-speed rail, MagLev, or aviation. The review has considered what Hyperloop's role could be if the technology is realized. Similarly, to the insufficient maturity of the technology, the potential application of Hyperloop is also still somewhat unclear. Originally proposed as direct competition to inter-city rail travel, the possible applications continue to evolve as cross-country, commuter and freight applications are considered.

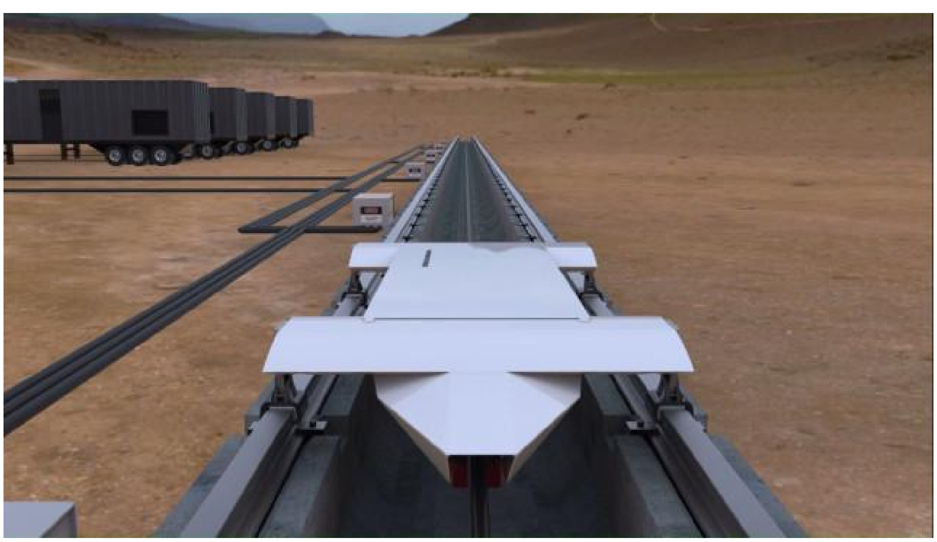

Fig:1*https://www.engineering.com/story/story/engineering-the-hyperloop-testing-4-core-elements*

2

Literature Review

2.1 Semester 7 work

2.1.1 Introduction The research work on this paper aims to develop an unmanned aerial vehicle equipped with modern technologies for various civil military applications. It's an automatic system. The shrinking size and increasing capabilities of microelectronic devices in recent years has displayed the doors to more capable autopilot and pushed for more real time UAVs applications.

Fig2:*https://www.freightwaves.com/news/technology/hyperloop-for-freight-could-be-faster-and-cheaper-than-air*

A quad-rotor helicopter (quadcopter) may be a helicopter which has four equally spaced rotors, usually arranged at the corners of a square body .The quadcopter is that the advanced sort ofhelicopter.A helicopter could be a flying vehicle which push air downwards by using rapidly spinning two rotors.The quadcopter uses four rotors. because the quadcopter uses four rotors, it's found to be quite difficult to regulate these rotors with no electronic assistance.

2.1.2 Review: Quadcopter flight dynamics- For controlling the altitude a selected style of controller is employed. When the controller is moved up or down, the propeller speed is adjusted causing the quadcopter to realize or lose altitude and also some way to regulate thrust of the rotors via voltage supply to perform standard flight operations and to position the quadcopter into certain angular orientation counting on the circumstances of a specific flight routine. Thrust is one sort of force. The movement of the aircraft relies on the rotational speed of every of the narrow airfoils; change of speed changes the position. The aircraft primarily is governed by control of the three major axes namely; pitch, roll and yaw. There are numbers of forces in space which might disturbed the motion of the quadcopter.

Structure Of Quadcopter: The main a part of the quadcopter is frame which has four arms.The frame should be light and rigid to host a LIPO battery, four brushless DC motors (BLDC), controller board, four propellers, a video camera and differing types of sensors together with a light-weight frame.

Problem Description

a. Designing, testing and certifying sensors, radar and camera able to observe any environment the drone may encounter particularly in adverse weather.
b. Developing, testing and certifying software that's functionally safe and secure.
c. Increasing travel distances and carrying capacity by improving aerodynamics, reducing weight and increasing battery or propulsion system performance.

Security and privacy are two other challenges we are going to be addressing during this project. Indeed, this can be a vital topic which still lacks maturity especially within the field of vehicular communications where the actual fact that the communications have to be made very quickly makes it difficult to accommodate strong security and privacy mechanisms that are often eager in terms of your time processing. Moreover, another pertinent challenge is to preserve the privacy of the sensitive information from the vehicles and drones (e.g., location). Hence, during this project, we are going to have a look at the impact of introducing flying nodes within the network and suggest effective privacy-preserving solutions.

2.2 Semester 8 Work

2.2.1 Introduction: The Hyperloop concept was first introduced in 2013 with the release of Elon Musk's Alpha paper. The paper outlined Hyperloop, a new transportation mode that utilized low-pressure tubes to propel capsules at high speeds over significant distances. The white paper was designed to be a launching point for innovation of the concept. To promote the Hyperloop concept, SpaceX, a private aerospace company owned by Elon Musk, initiated the Hyperloop Pod Competition in 2015, focused on the development and testing of a subscale prototype of Hyperloop. As one of the most successful teams in this competition, the Hyperloop team from Massachusetts Institute of Technology (MIT) unveiled the first scaled Hyperloop prototype in May 2016 and later demonstrated the first-ever Hyperloop run in a vacuum environment in January 20171. Since the release of the Alpha paper several Hyperloop companies in North America and Europe have been formed and continue to develop their own Hyperloop technologies, with the aim of advancing it to a level suitable for commercial deployment.

Fig 3: *https://www.constructionnews.co.uk/tech/virgin-hyperloop-ready-safety-test-27-11-2019/*

3

PROBLEM DESCRIPTION

3.1. Introduction: That's the huge, multibillion dollar and, as yet, unanswered -- question around Hyperloop. The concept has been around for a long time, but until now the technology has been lacking. This time around, it's possible that the technology may have just caught up with the concept. There are well-funded companies racing to be the first to deliver a working service but, despite their optimistic timescales, these projects are still very much in the pilot and experimental stages. Going from short test routes to hundreds of kilometres of track is a big jump that none of these firms has made yet. If the technology is still in development, that's also very true of the business models to support it. The success of Hyperloop will vary depending on the destinations, local economics, and geography. Trying to build a new line overland across England, for example, can prove an expensive and complicated business which can take many years (as the ongoing HS2 controversy has shown). In other countries where land is cheaper or where routes can travel through less populated areas, it may be easier to get services up and running faster. Capacity is another issue. It's not clear that Hyperloop can do a better job of moving a large number of people than other mass transit options. Critics argue that lots of pods will be required to achieve the same passenger numbers as more traditional rail, which uses much bigger carriages. And there are many engineering hurdles to overcome, like building the tubes strong enough to deal with the stresses of carrying the high-speed pods, and finding energy- and cost-efficient ways to keep them operating at low pressure. Moving from a successful test to a full commercial deployment is a big jump, and passenger trials are still to come. Assuming that consumers are happy being zoomed around in these tubes, finding the right price for the service will be vital, too.Right now Hyperloop is at an experimental stage, even if the companies involved are very keen to talk about its potential.

Fig3: *https://www.bgr.in/news/heres-how-the-hyperloop-system-works-841389/*

3.2 Problem Description: The companies building Hyperloop services argue that they are significantly cheaper to build than high-speed rail services. Musk's Hyperloop Alpha paper claimed his LA to San Francisco route could be built for one-tenth of the price of a high-speed rail alternative. Other companies have said their services could be one-third to half the price of rail services and much faster. Being cheaper to build should mean these services can become profitable quickly. However, there are plenty of engineering challenges to be tackled which could push the costs up, and how these services will be funded in the first place is not clear; many of the feasibility studies under way are looking at how to finance them, likely through a combination of public and private investment. Assuming all goes well, an operational demonstration track will be built between two points on the route two to three years from the signing of the agreement and serve as a platform for testing. The company said the construction of the full Pune-Mumbai route -- a 25-minute journey -- would take place in five to seven years. It added the high-capacity passenger and cargo Hyperloop route could eventually see 150 million passenger trips annually. The company is also working on a feasibility study into a Hyperloop route linking Kansas City, Columbia, and St Louis running along the I-70 in Missouri, and is looking at high-level cost estimate and funding model recommendations. The company has a 500 meter-long DevLoop, which has a diameter of 3.3m and is located 30 minutes from Las Vegas in the Nevada desert. In December, the company said it had completed its third phase of testing, achieving test speeds of 387 kilometers per hour.

"The tests were conducted in a tube depressurized down to the equivalent air pressure experienced at 200,000 feet above sea level. A Virgin Hyperloop One pod quickly lifts above the track using magnetic levitation and glides at airline speeds for long distances due to ultra-low aerodynamic drag," the company said.

Fig: 4 *https://qz.com/india/1265580/virgin-hyperloop-ones-promise-make-in-india-create-jobs-fix-outdated-transport/*

3.3 Engineering Challenges:

A. Given that the tube operates under a low-pressure environment and the anticipated operating arrangement for the pumps would mean they are not constantly running, it is predicted that the impact of a pump or two being down concurrently should not adversely impact operations and overall maintenance needs. It is not known at this time how long it would take to depressurize each segment as it is dependent on the number of pumps installed, their power-rating (i.e. high-cost and short pump-down time, or low cost and long pump-down time), and the length of each tube section.

B. Electrical power substations, where applicable, are likely to be similar in design to those used in present-day MagLev systems because Hyperloop substations will be powering the same types of components and are expected to require a similar or lower power supply14. Although several designs currently proposed by technology companies suggest power could be delivered through renewable energy sources, no details have been provided and the feasibility of such an approach remains unknown.

4

METHODOLOGIES

4.1 Semester 7 work

4.1.1 Proposed Outcome: A closed-circuit television with the assistance of a quadcopter can increase the safety strength especially within the area where human interference is strictly prohibited. All told, civilized countries' surveillance of the terrestrial areas is extremely important.The core intention is to review the whole designing process of quadcopter from the engineering prospective and improve their balancing and stability system.A quadcopter that's wirelessly controlled by a computer may be a challenging task. Security and privacy are two other challenges we will be addressing in this project. Indeed, this is an important topic which still lacks maturity especially in the field of vehicular communications where the fact that the communications need to be made very quickly makes it difficult to accommodate strong security and privacy mechanisms that are often eager in terms of time processing. Moreover, another pertinent challenge is to preserve the privacy of the sensitive information from the vehicles and drones (e.g., location). Hence, in this project, we will look at the impact of introducing flying nodes within the network and suggest effective privacy-preserving solutions.

4.1.2 Components to be Used: A quadcopter consists of the following essential parts:

A. Frame: The frame of a quadcopter is the main structure, or the skeleton upon which the rest of components will be attached. Once you have decided on what you want your craft to do (Aerial Photography, Racing, Micro Freestyle etc.), you need to decide what size best suits your requirements. The size of the frame will determine what size props you will use (or vice versa), in turn the size of the props will determine the size of the motors, which will specify the current rating of your ESC's.

B. Motors: The motors are the main drain of battery power on your quad, therefore getting an efficient combination of propeller and motor is very important. Motor speed is rated in kV, generally a lower kV motor will produce more torque and a higher kV will spin faster, this however is without the prop attached.

C. ESC (electronic speed controller): An ESC is a device that interprets signals from the flight controller, and translates those signals into phased electrical pulses to determine the speed of a brushless motor. Make sure that both your FC and ESC's are capable of running the same ESC protocol ie. DShot 600. When selecting an ESC, remember that the current rating must be higher than the amperage drawn by your combination of motors and props.
D. Propeller: There are possibly thousands of different types of propeller for quadcopters, with multiple options in almost every size. A heavier propeller will require more torque from the motor than a lighter prop, also blades with a higher AOA (Angle Of Attack – aka "aggressive props") encounter more resistance from the air and require more torque. When a motor has to work hard to turn, it draws more Amps. Finding a balance between the thrust produced and the amperage used by the prop and motor combination is a balancing act that every quad pilot goes through, there is no "right answer".
E. Battery: LiPo batteries are the power sources of the quadcopters. LiPo is used because of the high energy density and high discharge rate.
F. Flight Controller: The Flight Controller (aka "FC") is the brain of a quadcopter, it has sensors on the board so it can understand how the craft is moving. Using the data provided by these sensors, the FC uses algorithms to calculate how fast each motor should be spinning for the craft to behave as the pilot is instructing via stick inputs on the TX (Radio Transmitter). Most of the wiring on your quad will be focussed around the FC.
G. RC Receiver: Transmitters (TX) and receivers (RX) are not universal and you need to buy an RX that is compatible with your TX, an FrSky Taranis transmitter cannot work with a FlySky receiver. These days it is most likely that you will be using either PPM or a digital Serial protocol, which will only require 1 signal wire for all of the channels, plus power (3.3v or 5v) and GND.The signal wire will be connected to one of the UART terminals on your FC (Flight Controller). Some FC's actually have integrated receivers, if you are taking this route make sure that it is using a compatible protocol.

4.1.3 Block Diagram

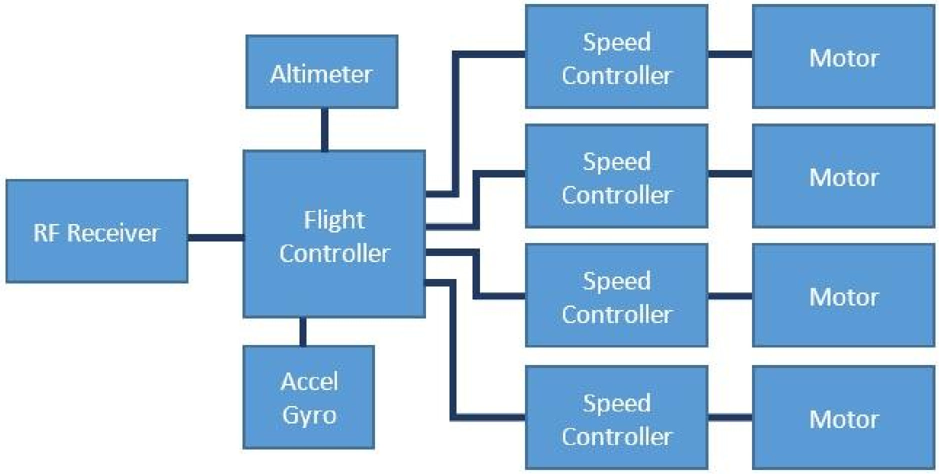

Fig 6: *http://www.innovatefpga.com/portal/index.html*

4.2 Semester 8 Work

4.2.1: Proposed System: Since the Hyperloop concept was first conceived, less than ten years ago, significant investment and testing has taken place to establish the feasibility of key principles and certain subsystems required to realize this technology. This section will review the fundamental engineering design considerations of the Hyperloop concept, to assess whether initial claims made about the performance of the technology are credible, and to establish which elements of the system need further refinement.

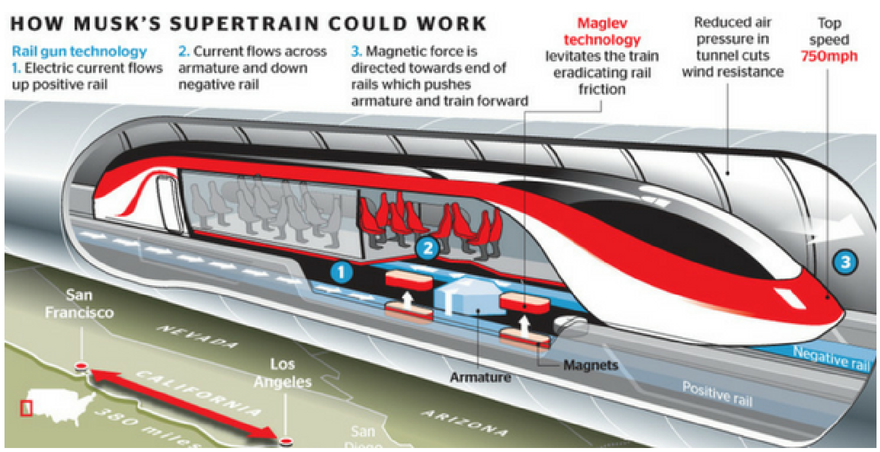

Fig 5: ***https://www.stumagz.com/10-facts-you-need-to-know-about-hyperloop/***

To date (March 2020), all Hyperloop technology developers have proceeded with designs based on the use of low-pressure tube environments maintained by vacuum pumps. The tubes provide a low friction system for the high-speed, low-energy movement of vehicles and, as the environment being used by the various developers is the same, the most substantial differences lie in the design of the various components responsible for frictionless travel, both on the pod and within the tube. These features are the major focus of the analysis, and are predominately based on propulsion, levitation, guidance, and power delivery.

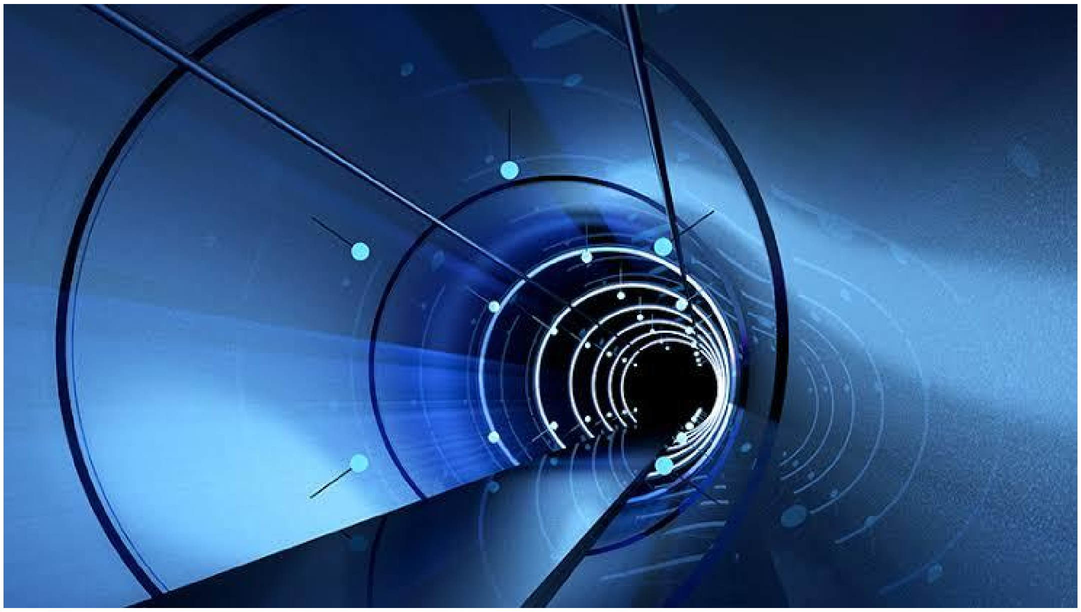

Fig 6: https://www.imeche.org/news/news-article/%27serious-engineering-analysis-shows-hyperloop-is-decades-away

A. The primary infrastructure feature of the Hyperloop system is a continuous low-pressure tube connecting two locations that would either be installed underground, effectively creating a tunnel, or elevated above ground using pylons.
B. The below surface format is less preferable due to the cost of boring/cut and cover construction techniques and potential existing utility conflicts. The above-ground design allows for easier access maintenance and security, a lower infrastructure footprint relative to most other transport infrastructure installed at-grade, and the potential for increased corridor capacity in congested areas.
C. A clear benefit of the pressurized tube, whether constructed underground or elevated, is that it can potentially protect the system from adverse environmental effects, such as flooding or bad weather, and removes the possibility of vegetation or wildlife impeding the path of the vehicles, notionally reducing maintenance costs and the risk of service disruption along the corridor.
D. Independent research also suggests that current code-based design regulations across the globe are insufficient for the design of such

systems. However, this analysis assumes that the tube is made of steel; an alternative is precast fibre-reinforced concrete, which may offer higher stiffness at a lower cost.

E. The concept of track-switching for MagLev technologies is not completely unproven, some of the existing systems currently employ a mechanical based switching system on their networks, but this is limited to very low speeds. Due to the complexities of the system and the tolerance of the mechanical systems, the switching occurs at significantly slower speeds than the operational maximum.

4.2.2 Block diagram

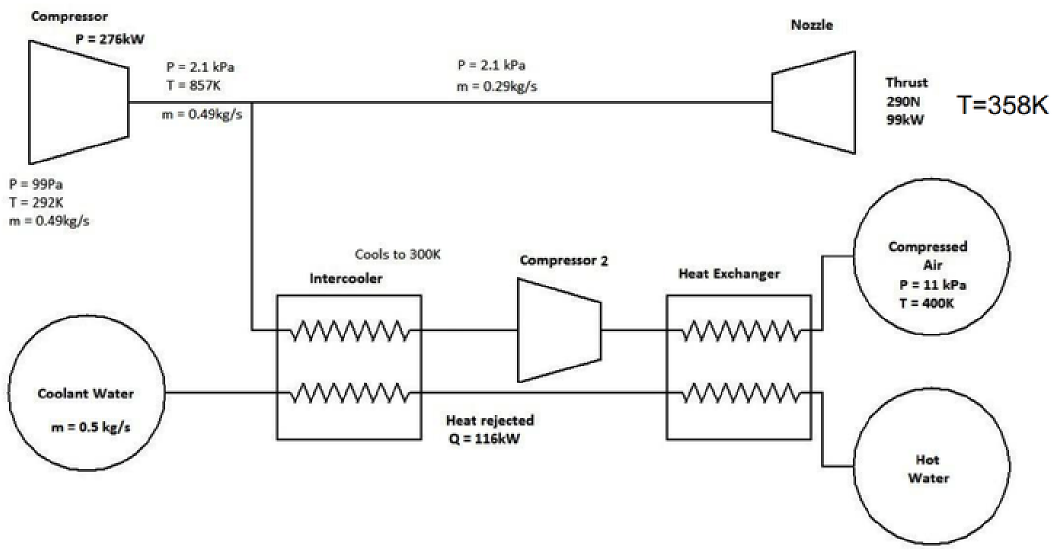

Fig 7: *https://www.nikhilchari.com/hyperloop.html*

4.2.2 Components Used

The Hyperloop: 4 Core Elements:

A. The Big Tube: a 12’ diameter tube which can support an ultra-low pressure (ULP) environment. Their aim is to reduce the pressure inside the tube to one thousandth of an atmosphere (equivalent to approximately 160,000-foot elevation). This would substantially reduce drag; a pod moving through the tube at 700 mph would experience drag equivalent to a transport trailer travelling on a highway at 60 mph.

B. The Compressor: an axial compressor capable of functioning in an ULP environment. Although Hyperloop Technologies has been working extensively on these challenges with modelling and simulation, everything will need to be adjusted in light of actual test data. Enter the Blade Runner: a unique wind tunnel that was designed, analyzed and built in ten weeks. It’s capable of running continuously and testing at supersonic speeds.

C. Levitation: a method for lifting the pods that will work in an ULP environment.

D. Electric Propulsion: a linear motor to accelerate the pods within the tube. Currently, electric motors are the most attractive propulsion option for the Hyperloop. There are two basic kinds of linear electric motors: induction and synchronous. The former are more common in the industry, but Giegel hinted that the company may be opting for the latter.

5

RESULTS

This study aims to undertake a holistic assessment of the viability and readiness of the rapidly evolving emergent technology referred to as “Hyperloop”, for high-speed passenger and freight transportation in the Canadian context. A central objective has been to better understand, examine and determine, in the general sense, whether safe, large-scale application of this technology in Canada can be delivered with comparable or lower lifecycle cost to existing transportation modes such as high-speed rail and MagLev.

Using a combination of industry insight, available material, developer input, and transportation consultant expertise, the study has provided:

A. review of the publicly available literature on Hyperloop (as of March 2020);
B. a review and assessment of the major engineering components of the Hyperloop system;
C. an objective overview of potential risks and hazards associated with the system as they pertain to regulating bodies;
D. and an initial/early look at the estimated capital and operating costs of a hypothetical system through a financial/economic lens.

Hyperloop as a technology has only received widespread public attention since 2013, when Elon Musk published his white paper on the subject. The theory of vacuum-based transportation was first developed in the early twentieth century with the realization that removing the air around a train would allow acceleration with less energy expenditure. Since then, the concept of vac-trains has been posited by many different engineers, but no scaled design has ever been commercially pursued.

A defining feature of the model Musk proposed is a low pressure rather than zero pressure environment, which he claimed was more achievable in a commercial setting. He also proposed that capsules should not run on tracks, as this would create too much friction. Instead, they would float on cushions of air (although subsequently, the use of magnetic levitation has developed into the preferred approach). Since the Alpha paper publication, many academic and commercial developers have sought to further refine the concept and progress it to the level of a commercially viable transportation mode.

Hyperloop is intended to offer a new form of travel for both passengers and freight with fast and price competitive transportation links. With forecast top speeds between 1,000-1,200 km/h, this primarily ground- based transportation mode has the potential to change inter-city and longer distance travel. Despite the potential for significant journey time savings over other established modes, Hyperloop is targeted at a particular niche demographic for whom it will hold the greatest appeal. Considered to be a hybrid of rail and air travel, incorporating the best of both modes, it is still constrained by the need to operate on its own infrastructure, thus requiring a significant level of demand to make construction feasible for any particular corridor. These conflicting limitations, among other factors, are why Hyperloop is not seen as a significant competitor to automobiles.

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CONCLUSION

That significant effort and investment is going into this development reflect the belief that a viable solution is achievable. However, despite the progress to date, there remain several challenges to overcome:

A. - Anticipated Speed – The proposed maximum speed will be between 1,000 km/h and 1,200 km/h (depending on the developer). However, such speeds have yet to be demonstrated in any real-world environment. Speed being one of the main selling points of the system, a failure to operate at anything close to these will sufficiently diminish the viability of the mode in many scenarios.
B. Environmental Impacts – As a new technology, the hope was that this could be close to a zero- emission mode. However, if the energy supply must be drawn from the main grid this will harm the environmentally friendly image. Equally, issues regarding noise, vibration and visual impacts are yet to be fully understood and could also tarnish the clean, green image.
C. Technical Components – Several technologies, such as high-speed non-mechanical switching, terminal portals and Hyperloop compatible communication systems, remain unproven. These elements will need to be developed and validated at speed before the system can be considered fully feasible.
D. Capital Costs – The estimated capital costs for developing a system will need to be carefully managed to remain competitive with alternatives. This will prove challenging, with costs already rising and the additional requirements for regulatory approval not yet factored in.
E. Governance – To become a realized mode, and for a network of routes to be developed, regulatory agencies at different levels will need to collaborate to develop a governance and regulatory structure to mitigate risks and support the implementation of Hyperloop

Hyperloop remains an exciting technology capable of changing our perception of travel and transportation in the traditional sense. Given humankind’s achievements over the last decade alone, there is no doubt that certain technological hurdles will be overcome with advancements in digital and electronic technology. However, important issues remain surrounding safety, security, and operations. The challenges may not be insurmountable, as demonstrated by the strides taken during the infancy period of the technology. But to speculate on when Hyperloop will mature to a stage where it can be implemented commercially is not possible at this time. Given the remaining obstacles, it is difficult to see an operating passenger Hyperloop pod until well into the next decade at the earliest.

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FUTURE SCOPE OF THE PROJECT

As a way to measure the potential of the system, Hyperloop is being compared to existing transportation modes. For many possible Hyperloop applications, the primary alternatives are high-speed rail and MagLev. The technical specifications of Hyperloop (if fully realized), would give it a significant advantage in terms of speed over the other modes, but the claim that it could be delivered at a lower cost is now in doubt. This likely means the application of Hyperloop will occur in less price-sensitive corridors, where journey time savings are more important to the demand base than price.Hyperloop remains an exciting technology capable of changing our perception of travel and transportation in the traditional sense. Given humankind's achievements over the last decade alone, there is no doubt that certain technological hurdles will be overcome with advancements in digital and electronic technology. However, important issues remain surrounding safety, security, and operations. The challenges may not be insurmountable, as demonstrated by the strides taken during the infancy period of the technology. But to speculate on when Hyperloop will mature to a stage where it can be implemented commercially is not possible at this time. Given the remaining obstacles, it is difficult to see an operating passenger Hyperloop pod until well into the next decade at the earliest.

Appendix

Plagiarism Report: Semester 8

kendy4

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