Hyperloop, The New Transport System

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***Abstract* – The conventional modes of transportation of people consists of four unique types and that are rail, road, water, and air. These modes of transport tend to be either relatively slow, expensive or a combination of both. Hyperloop is a new mode of transport that seeks to change this pattern by being both fast and inexpensive for people and goods. Hyperloop is a proposed mode of passenger and freight transportation that propels a capsule-like vehicle through a near-vacuum tube at more than airline speed. The pods would accelerate to cruising speed gradually using a linear electric motor and glide above their track using passive magnetic levitation or air bearings. The capsules are supported on a cushion of air, featuring pressurized air and aerodynamic lift. Passengers may enter and exit Hyperloop at stations located either at the ends of the tube, or branches along the tube length.**
The purpose of this report is how dramatically the Hyper loop could change transportation, road congestion and minimize the carbon footprint globally. If both people and goods can move more quickly and comparatively cheaply, rapid growth is a logical outcome.

Key Words: Hyperloop, Electromagnetic Levitation, Vacuum Tube, Capsule, Linear Electric Motor, Air Bearings, Aerodynamic track, Electromagnetic Propulsion, Renewable Energy Penetration, Sustainability

1. PROBLEM DESCRIPTION

As we know that there are four modes of conventional transportation. First is rail which is relatively slow and expensive, another is road and water which is relatively slow and next is air which is too expensive. Road travel is particularly problematic, given carbon emissions and the fluctuating price of oil. As the environmental dangers of energy consumption continue to worsen, mass transit will be crucial in the years to come.

Developments in high-speed rail have historically been impeded by the difficulties in managing friction and air resistance, both of which become substantial when vehicles approach high speeds. Rail travel is relatively energy efficient and offers the most environmentally friendly option, but is too slow and expensive to be massively adopted. At distances less than 900 miles, supersonic travel is unfeasible, as most of the journey would be spent ascending and descending

Given these issues, the Hyperloop aims to make a cost effective, high speed transportation system for use at moderate distances.

2. INTRODUCTION

Hyperloop is a completely new mode of fastest transportation. Hyperloop was firstly proposed by Elon musk and a team of engineer from Tesla Motors and the Space Exploration Technologies Corporation in August 2013. The concept of Hyperloop includes travelling people from one place to another place in a capsule which is propelling at a very high speed. Basically Hyperloop is magnetically levitated train which runs inside a long tube or pipe. It consists of low pressure tube with capsule that is transported at both low and high speeds. It is driven by linear induction motor and compressor. It includes 28 passenger pods.

For propulsion, magnetic accelerators will be planted along the length of the tube, propelling the pods forward. The tubes would house a low pressure environment, surrounding the pod with a cushion of air that permits the pod to move safely at such high speeds, like a puck gliding over an air hockey table.

Given the tight quarters in the tube, pressure buildup in front of the pod could be a problem. The tube needs a system to keep air from building up in this way. Musk's design recommends an air compressor on the front of the pod that will move air from the front to the tail, keeping it aloft and preventing pressure building up due to air displacement. A one way trip on the Hyperloop is projected to take about 35 minutes (for comparison, traveling the same distance by car takes roughly six hours.) Passengers may enter and exit Hyperloop at stations located either at the ends of the tube, or branches along the tube length.

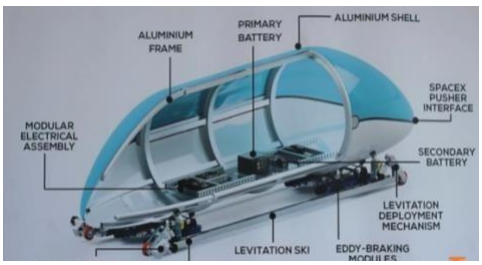


Fig1: *Hyperloop Based System*

3. BASIC PRINCIPLE OF HYPERLOOP

Hyperloop is based on a principle of magnetic levitation. The principle of magnetic levitation is that a vehicle can be suspended and propelled on a guidance track made with magnets. The vehicle on top of the track may be propelled with the help of a linear induction motor.

Virgin Hyperloop Concept

Fig 2: *The Virgin Hyperloop*

The concept of Hyperloop transportation was first introduced by Robert Goddard in 1904. Virgin Hyperloop One has made substantive technical changes to Elon Musk's initial proposal and chose not to pursue the Los Angeles–to–San Francisco notional route that Musk envisioned in his 2013 alpha-design white paper.

Virgin.Hyperloop (formerly Hyperloop Technologies, Hyperloop One and Virgin Hyperloop One) is an American transportation technology company that works to commercialize the high-speed technology concept called the Hyperloop

Hyperloop One has completed a 500-meter Development Loop (DevLoop) and on May 12, 2017, held its first full-scale Hyperloop test. The test combined Hyperloop components including vacuum, propulsion, levitation, sled, control systems, tube and structures. As of May 2019, the company had raised $400 million. Its publicly stated goal is to provide a fully operational Hyperloop system by 2020 or 2021.

On November 8, 2020, after more than 400 unmanned tests, Virgin Hyperloop conducted the first human trial with Virgin Hyperloop executives Josh Giegel, its Chief Technology Officer, and Sara Luchian, Director of Passenger Experience as the first passengers at a speed of 172 km/h (107 mph) at the Virgin Hyperloop's DevLoop test site in Las Vegas, Nevada

4. CONSTRUCTION

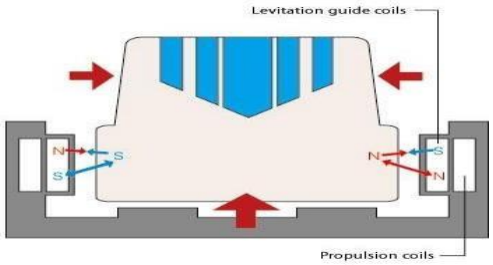


Fig 3: *Stator and Rotor Coils Arrangement*

41 Tube:

The tube is made of steel. There are two tubes which are welded together side by side configuration to allow the capsules travel in both directions. The tube will be supported by pillars.

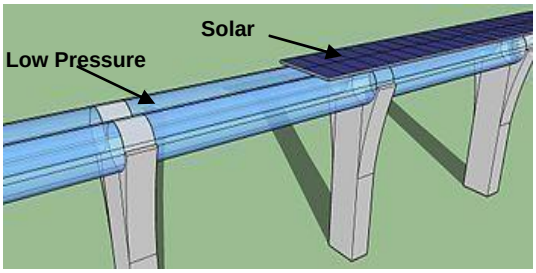


Fig 4: *Construction of tube*

42 Capsule:

The capsule can carry 28 passengers at a time and it send at a very high speed and it is levitated by a high pressure air cushion. The design of capsule is start with the aerodynamic shape. There are two version of capsule are being considered: a passenger only version and a passenger plus vehicle version.

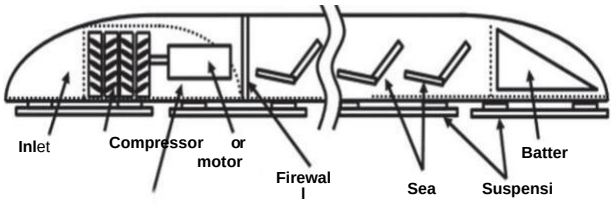


Fig 5: *Arrangement in capsule*

43 Compressor:

The compressor is fitted at the front side of the capsule. It supplies the air to the air bearings which supports the weight of the capsule. The compressor allows the capsule to traverse to the low pressure tube without choking the air flow that travels between tube walls and capsule.

Fig 6: *Compressor*

44 Suspension:

Air bearing suspension offers stability and extremely low drag at a feasible cost. A stiff air bearing suspension is superb for reliability and safety. When there is a gap between ski and tube walls is high then it shows the nonlinear reaction and which results in large restoring pressure.

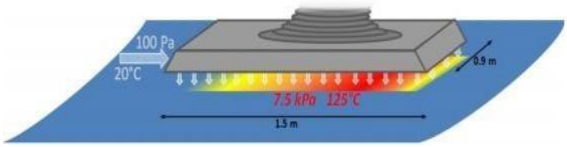


Fig 7: *Schematic of air bearing skis that support the capsule*

45 Propulsions:

To accelerate and decelerate the capsule the linear induction motor is used in hyperloop system. It provides some advantages over a permanent magnet motor. To accelerate the capsules there is linear accelerators are constructed on a length of the tube. Stators are placed on the capsules to transfer momentum to the capsules via the linear accelerators.

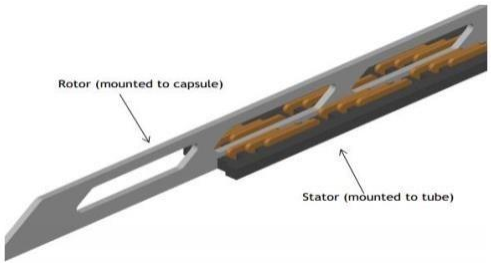


Fig 8: *Propulsion*

5. WORKING OF HYPERLOOP SYSTEM

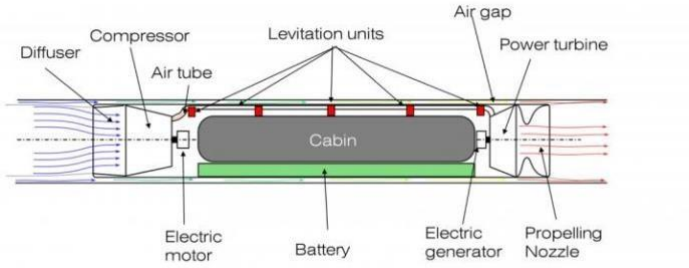


Fig 9: *Working of Hyperloop system*

Working of Hyperloop system is based on magnetic levitation principle. As we know that the passenger pod travels through low pressure tube which is pylon-supported tube.

In Hyperloop system an air compressor fan is fitted on front side of pod which sucks the air. It transfer high pressure air front side to the rear side of capsule (pod) and it propel the pod. It creates the air cushion around the pod, so that the pod is suspended in air within the tube.

On the basis of magnetic levitation principle the pod will be propelled by the linear induction motor. By the linear induction motor the capsule send from one place to another place to a subsonic velocity that is slower than the speed ofsound.

The pod will be self-powered. There is solar panel fitted on top of the tube. By this solar panel there is enough energy is stored in battery packs to operate at night and in cloudy weather for some periods. The energy is also is stored in the form of compressed air.

The air between the capsule acts as a cushions to prevent two capsules from colliding within the tube.

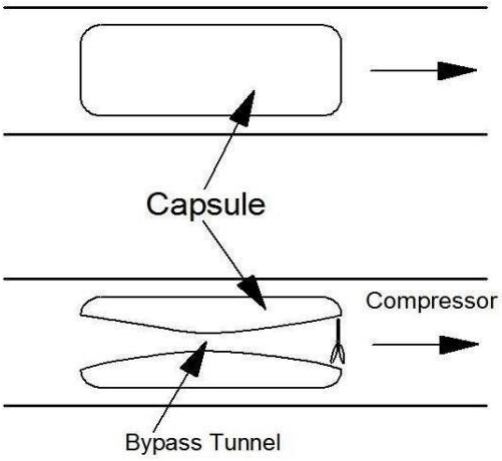


Fig-10: *Air through bypass tunnel*

In above figure it shown that the air through the compressor is send to a bypass nozzle at the rear end of the capsule. If capsule cover too much area of the tube then, the air is not flow around the capsule and ultimately the entire column of air in the tube is being pushed ahead of the capsule and because of this there is friction between the air and tube walls is increases tremendously. Therefore to avoid this problem the compressor is fitted at the front of the capsule through which the air will not flow around the capsule and send it to bypass nozzle.

6. DESIGN METHODOLOGY

The objective of our project was to design a "**High Speed Hyperloop Based Transportation System"** which will prove to be a source of fast and economic transportation

Initially we had taken a capsule of mild steel which replicates the actual train (pod or capsule) and it would pass through a PVC pipe 7ft long which serves the purpose of a channel for the train.

In practical approach, the train uses principle of electromagnetic levitation or centrifugal principle, but in our model we have used the principle of electromagnetic propulsion for propelling the train.

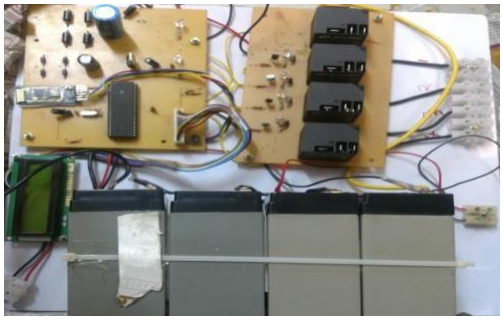


Fig 11: *Circuitry Designing*

We used four 6 Volt batteries connected in series to give 24 Volt supply required for energizing the coils

We used 12 Volt supply (by tapping two 6 V batteries) which is feed ATmega16(microcontroller). Firstly, this 12 V supply is given to capacitor filter to remove the ripple content. Then it is being fed to 7805 series voltage regulator which regulates the output voltage to 5 volts. This regulated output voltage is again filtered through capacitor filter to remove the ripple content and then it is being fed to ATmega16. The three main inputs of ATmega16 are:

1. Power supply
2. Reset circuits
3. Clock

The main function of ATmega16 was to provide the necessary control signals required for energizing the relay after a specified time delay (by clock) so as to ensure sequential excitation of the coils which facilitates the fast movement of the train.

As the output signals from ATmega16 are weak they were amplified through Transistor BC549 and then fed to the relay.

When the relay gets energized the NO contact gets closed, thereby completing the circuit of 24 Volt supply to the coils. In this way the first coil gets energized then the capsule gets attracted towards it.

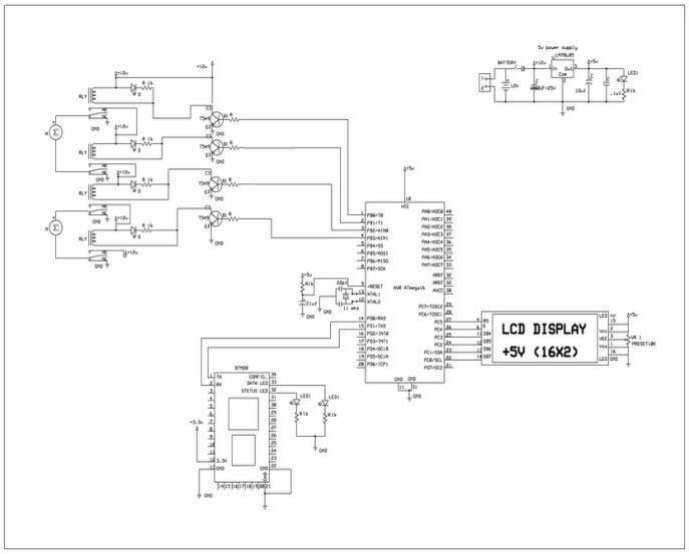


Fig 12: *Functional Block Diagram*

After a time delay of 65ms, the second coil is energized and it's NO contact gets closed thereby completing its circuit which results in coil to get attracted towards it, whereas the supply to the first coil is stopped. Similarly, the procedure is repeated for the remaining coils which ultimately results in fast movement of the train.

By exciting the coils in the sequence 1-2-3-4 we obtained forward movement of the capsule. To obtain reverse movement, the excitation sequence should be 4-3-2-1.

ATmega16 is programmed using C-language programming ATmega16 microcontroller is interfaced with 16x2 LCD display wherein we displayed name of the project, project guide, Time delay(eg:65ns), command prompted(forward, reverse).

ATmega16 is programmed using C language. The frequency of crystal oscillator (clock) is 11.0592MHz.

From port D of ATmega16, TXD and RXD pins are interfaced to RXD and TXD pins of the Bluetooth module. Software used is HC05. The Bluetooth is connected to mobile app via B4A (Basics For Android) software. By using this mobile app, we controlled the capsule movement and provided the required time delay

The project proposed is a real time working project, and this can be further improvised by using sensors (infrared, motion) and by incorporating non-conventional sources of energy.

Fig 13: *Working Prototype Model*

Materials	Specifications
Lead Acid Battery	SMF(Sealed Maintenance Free) 12volts 4.5AH
Pipe	PVC 7ft(Length) 2.5 Inches(Diameter)
LCD Display	16x2
Copper Wires(Coils)	18 SWG, 200 turns
Voltage Regulator	7805 Series
Microcontroller	ATmega16 16kB ROM
Transistor	BC549
Diode	1N4007
Capacitor (Electrolytic)	1000µF & 1µF
Capacitor(Ceramic)	22pF & 0.1pF
Resistors	1kΩ
LED's	3Volts
Bluetooth Module	HC05
Crystal Oscillator	11.0592MHz
Rectifier	Bridge
Relay	SPDT Electromagnetic Type 12V, 25A
PCB	Phenolic Type
Wires	Copper & Aluminium
Mobile App	B4A software
Plastic preset	-
Capsule	Mild Steel (2.2 inches)

Table 1: *Specifications of Materials*

PROGRAM:

```
$prog &HFF , &HFF , &HDF , &H00
$regfile = "m16def.dat"
$crystal = 11059200
$baud = 9600
Config Lcd = 16 * 2
  Config Lcdpin = Pin , Db4 = Portc.4 , Db5 = Portc.5 , Db6
=     Portc.6 , Db7 = Portc.7 , E = Portc.2 , Rs = Portc.0
  Config Porta = Input
  Config Portb = Output
  Portb = 0
Dim T As Integer
Dim Indata As Byte

T = 65

Cls
Cursor Off
Lcd " Hyperloop"
Lowerline
Lcd " "
Wait 2

Cls
Lcd " M.H.S.S.P"
Wait 2

Cls
Lcd " Guided By: "
Lowerline
Lcd "Prof.M.K.Vani "
Wait 2


Do

Indata = Inkey()

Cls
Lcd "Coil Time:" ; T ; "Ms"

If Pina.1 = 0 Then
Lowerline
Lcd "forward"

Portb.0 = 1
Waitms T
Portb = 0


Portb.1 = 1
Waitms T
Portb = 0


Wait 1
End If

''''''''''''''''

If Pina.3 = 0 Then
Lowerline
Lcd "Reverse"

Portb.3 = 1
Waitms T
Portb = 0


Portb.2 = 1
Waitms T
```

```
Portb = 0

Wait 1
End If

''''''''''''''''''

If Indata = "1" Then
Lowerline
Lcd "forward"

Portb.0 = 1
Waitms T
Portb = 0


Portb.1 = 1
Waitms T
Portb = 0


Wait 1
End If

''''''''''''''''''

If Indata = "2" Then
Lowerline
Lcd "Reverse"

Portb.3 = 1
Waitms T
Portb = 0


Portb.2 = 1
Waitms T
Portb = 0

Wait 1
End If



If Indata = "3" Then
T = T + 5
Waitms 250
End If

''''''''''''''''''

If Indata = "4" Then
T = T - 5
Waitms 250
End If

Waitms 100

Loop
```

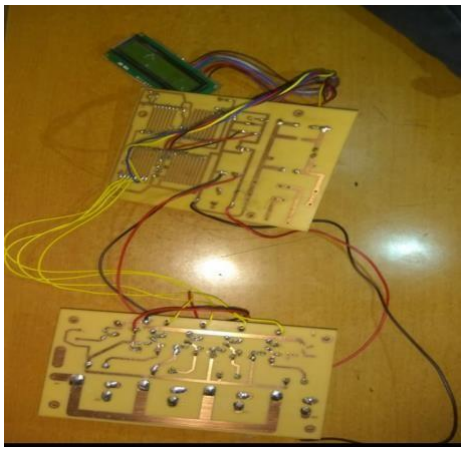


Fig 15: *LCD Interfacing*

Fig 16*: Channel Designing*

Fig 17: *Component selection, Sizing and Soldering*

7. MERITS AND DEMERITS OF HYPERLOOP TRANSPORTATION SYSTEM

7.1 Merits:

1. It saves the travelling time and energy.
2. There is no problem of traffic.
3. It can be powered by the solar panel.
4. It can travel in any kind of weather.
5. Not disruptive to those along the route.
6. More convenient
7. Ensures jerk free and comfortable travel of passengers

7.2 Demerits:

1. Turning will be critical.
2. Less movable space for passenger.
3. High speed might cause dizziness in some passenger.
4. Punctured tunnel could cause shockwaves.

8. CONCLUSION

A high speed transportation system known as Hyperloop has been developed in this report. Hyperloop transportation system can be used over the conventional modes of transportation that are rail, road, water and air as a fast and relatively economic means of transport. Further, it does not contribute to carbon emissions and landfill, thereby ensuring sustainable development.

9. HYPERLOOP IN INDIA

- Hyperloop Transportation Technologies are in process to sign a Letter of Intent with the Indian Government for a proposed route between Chennai and Bengaluru. If things go as planned, the distance of 345 km could be covered in 30 minutes.
- HTT also signed an agreement with Andhra Pradesh government to build India's first Hyperloop project connecting Amravati to Vijayawada in a 6 minute ride.
- On February 22, 2018, Hyperloop One has entered into a MOU (Memorandum of Understanding) with the Government of Maharashtra to build a Hyperloop transportation system between Mumbai and Pune that would cut the travel time from the current 180 minutes to just 20 minutes.

Fig 18: *Hyperloop One (India)*

FUTURE SCOPE

Now a day's cities are polluted, roads are crowed and travelling time is more and travelling experiences are now defined by chaos and calamities. Hyperloop is all about improving transportation infrastructure. It is time to use resources smartly, travel green and the cost of mass transit for everyone.

Hyperloop can be made of two versions namely Passenger only and Passenger plus Vehicle Hyperloop. Hyperloop is indeed a next generation mode of transport developed in this earlier generation.

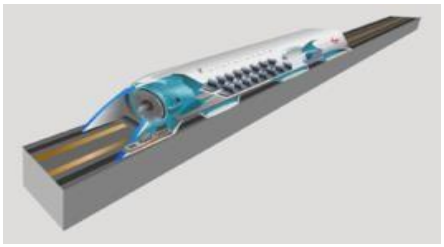


Fig 19: *Design Modifications*

The technology of Hyperloop is in its rudimentary stage. Although the technology is triple-crown, it can be worked upon for improvement in near future.

1. An in depth style for the stations, together with loading and unloading of passengers
2. Improved safety options and propulsion of the capsule.

One of the foremost challenges for Hyperloop is its adaptability to topography sharp turns and altering altitudes. The current capsule design permits solely 28 passengers to commute at a time.

Improvements can be made

1. By incorporating more space for passenger transport.
2. Effective and efficient use of Power Electronic Interface will reduce the risk of shockwaves, and increase passenger comfort and safety
3. Use of SCADA for remote monitoring and control
4. Employment of renewable energy resources like Solar, Wind etc. thereby ensuing sustainable development

The cost of Hyperloop has always proven to be a challenging question to many. But if observed practically, inspite of high initial cost, the payback period of Hyperloop is much lower (3-

5 years) in comparison with that of high speed maglev Trains (greater than 10 years) or Airlines (above 15 years).

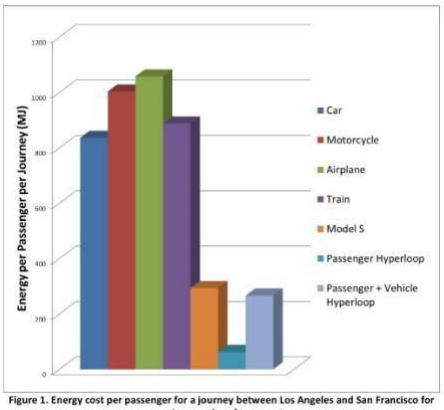
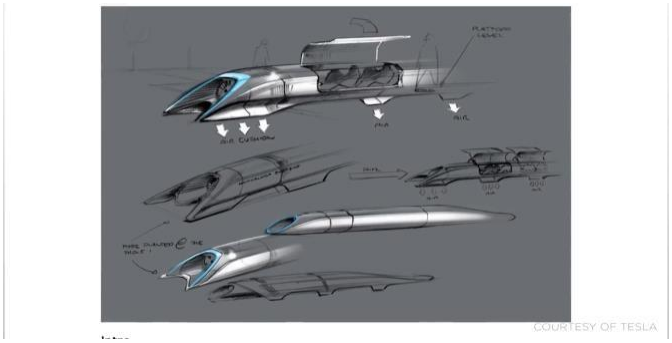


Figure 1. Energy cost per passenger for a journey between Los Angeles and San Francisco for various modes of transport.

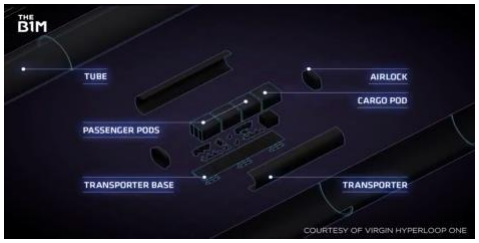
Fig 20: *Comparative analysis of cost/unit for varous modes of transport*

From here it can be seen that cost per unit will become significantly low in the years to come with proper technological advancement and research processes.

WORKING MODELS OF HYPERLOOP



Musk's Concept



B1M- Virgin Hyperloop One's Concept

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