

# Prospects of Hyperloop Transportation Technology: A Case of China

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## ABSTRACT

Hyperloop transportation technology is amongst the most promising sustainable and climate-friendly transportation systems of the modern era. Now China has taken steps to build this transportation system in Tongren city, which located on Guizhou's eastern part [8]. So far, not much work has been conducted on the prospects of this technology, especially for China. In this paper based on extensive literature review, we have analyzed the prospects of this technology in China. Furthermore, this article also discusses the possible hurdles and proposes some suggestions for overcoming the problems in the adoption of this climate-friendly technology.

**Keywords--** Hyperloop Technology, Sustainable Transportation Technology, Ultra-High-Speed Vactrain, New Prospective of Hyperloop Technology, Long-Distance Transport

## I. INTRODUCTION

Human civilization and transportation system both are intensively involved like the back of a coin. We are still looking for the methods of new transportation technology which should be cheaper and faster in the 21st century. Many scientists and engineers have tried to develop a new sustainable transportation system, but they failed to bring the system commercially. But in 2013, An open-source paper was proposed by ELON MUSK who is the founder, CEO, and lead designer of SpaceX; co-founder, CEO, and product architect of Tesla, Inc. known as “An Alpha Vision”, which describe the fifth mode of transportation system named Hyperloop after Rail, Water, Road, Air. Though this transportation system is in the conceptual stage, this performance would be a lot of times superior to high-speed rail and air transportation system and also reduce the travel time, transport costs, energy consumption with better safety. So far, Hyperloop Vactrain (vacuum train) based on three-part which is

1. Magnetic or air levitation
2. Linear motor proportion
3. Vacuum based transport system

“An Alpha Vision” paper has described by the fifth mode of sustainable transportation system can connect to big

American cities like Los Angeles to San Francisco. This new revolutionary transportation technology needs to transfer goods and passengers with a maximum speed of 760 mph. [1,2]

## II. HOW DOES THE SYSTEM WORK?

Basic elements of transportation technology are:

- The tube
- The capsule

### A. The Tube

Hyperloop is a tube-based transportation system. It uses two tubes, one for moving forward direction and another one for moving the opposite direction. The diameter and length of the tube are 2.23 m and 30 m. The tube is supported by pylons consecutively 100 ft along the tube. The thickness of the tube (For passengers' tube) is 20 to 23 mm. [1]



Figure 1: Tube of hyperloop [11]

### B. The capsule

The capsule is the vehicle for transferring passengers' which dimensions are 25-30 m in length, 1.1 m in height, and 1.35 m in width. It could carry 28 passengers at a time by providing two rows of seats with 14 seats in each row. It has a compartment for hand luggage of its passengers. As so far, the whole system could carry 840 people/hour, which means 7.4 million people/year. The movement of the capsule is carried out using linear electric motors. The moving motor element (rotor) is located on the bottom of the capsule while the tube incorporates the stationary motor element (stator), which powers the capsule. [1]

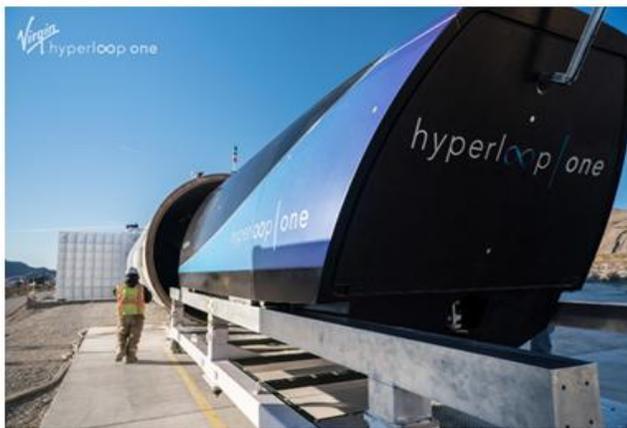


Figure 2: Pod of hyperloop [11]

## III. WORKING PRINCIPLE & FEATURES OF THIS NEW TECHNOLOGY

An Aluminum sheet works as a rotor for the engine located on the bottom. The stator bend produces a linearly moving magnetic field acting on the bottom surface of the capsule. In the transportation system, the main driver is the Aluminum sheets, which located in the area has vortex currents induced in it, in this way creating an opposite magnetic field. The two different magnetic fields force back each other and produce the motion of the capsule. It would not be challenging to accelerate the capsule to reach the velocity of 760 mph and deaccelerate it for the better and safer braking system.

The acceleration will reboot in a periodically every 110 km (roughly). There should have been a minimum interval time of 30 seconds between two side by side capsule. To get the maximum velocity, the friction should be very lower between capsule and tube. That is why Air cushion mode around the capsule is the right method to prevent the friction between capsule and tube. In the front part of the capsule, An Air compressor receives a counter flow of air to increases the incoming air pressure by 20 times. It feeds in specific proportions through a system of different parts of the capsule surface. As so far, the capsule

must move through the tube by air currents without touching the tube wall.

When a solid body moves in the air, air cushion pushes back from the front. The strength of resistance to movement increases with increasing speed of the body. For reducing air resistance, it is proposed to maintain a pressure of 100 Pa (1/1000 atmospheric pressure) in the tube. The vacuum pump system maintains the required reduced pressure.

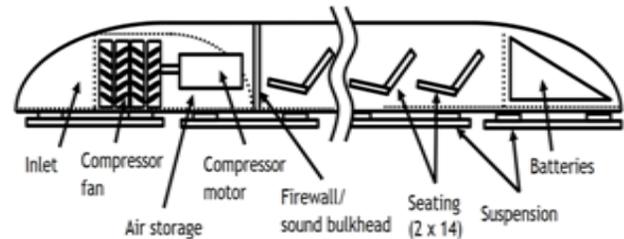


Figure 3: Hyperloop passenger pod subsystem notional locations (not to scale) [1].

The energy exhausted by using the air cushion is 21 MW. Solar panels are located on the outer surface of the tube to produce the power for the whole system. The cells could a massive amount of energy, almost 57 MW.

To get maximum speed from any high-speed transportation system, the path should be straight line. Therefore, Hyperloop tube should be a straight line as possible as we can. Due to the curvilinear nature of the route in urban areas of Los Angeles and San Francisco, the capsule reduces the speed on these sections of the road.

In 2016, the work already had begun; it is planned to finish the project in 2020. Elon Musk estimates the costs of this project at \$ 6 billion for only passenger capsule [1]. Two companies, Hyperloop One and Hyperloop Transportation Technologies (HTT), began to work for this project. They have involved in solving technical problems associated with the new technology.

They have built an experimental testing grounds and have started for reality of specific projects in the US and other countries. The NTT is working to the realization this project in California. It also has initial agreements with other countries like Central Europe, United Arab Emirates (UAE), and From Asia (China & India) for the development of Hyperloop passengers project. In 2016, Hyperloop One organized a worldwide competition to select places where the first hyperloop project will begin. It made awareness among Individual citizens, universities, firms and government organizations from different countries who took part in this competition. The proposals should outline the need to use new ultra-high-speed transport technology to move goods and people in this particular place. As a result, the company received 2600 offers from individuals and organizations for five months. The company is establishing contact with Russia to construct of an

experimental hyperloop cargo line 65 km long from Russian seaport Zarubino. Also, China has taken steps to construct this new technology located in Guizhou province[3,4].

#### IV. SOME TECHNICAL ISSUES OF THE NEW TRANSPORT SYSTEM

We discuss some technical features of the Hyperloop transportation system, the critical technological and economic indicators as well. For the passenger hyperloop from Los Angeles to San Francisco, the diameter of the tube is 2.23 m, and its cross-sectional area is 3.91 square meters. The passenger capsule’s length, height, weight is respectively 25 m, 1.1m, 1.35m. The frontal projection area of the capsule is 1.4 square meters. Though the tube will be low air pressure, the capsule should be aerodynamic shape to the air drag. Aerodynamic coefficients connected to Kantrowitz Limit. The ratio of the capsule frontal projection area to the cross-section area of the tube  $\alpha = 36\%$ , the ratio of diameters  $\beta = 68\%$ . The total weight of the passenger capsule with all equipment, including 28 passengers is 15,000 kg [1].

For cargo transportation, capsules will be different from passenger-only capsules, where the length is larger, the area of frontal projection is 4 square meters, the required diameters are increased up to 3.3 m; the cross-sectional area is 8.55 square meters. Aerodynamic coefficients would change to  $\alpha = 47\%$ ,  $\beta = 68\%$ . The total weight of the cargo capsule including passengers is maximum 26,00 kg. [1] The capacity of carrying passengers and goods can be increased both by increasing the maximum capability of the capsules and numbers of tubes of the road [8].

Table I  
Total Cost Of Passenger Hyperloop[1]

Component	Cost (million USD)
Pod structure & doors	9.8
propulsion	5
Inside & Seats	10.2
Plumbing & Compressor	11
Air Bearings & Suspension	8
Electronics & Batteries	6
Propulsion	5
Component Assembly	4
Pylon Building	2550
Tube Building	650
Tunneling	600
Propulsion for tube	140
Batteries & Solar cells	210
Vacuum Pumps & Station	260
Land & Permits	1000
Cost Edge	536
Total Cost	6000

#### V. COST TO THE REALIZATION OF THE NEW TRANSPORTATION TECHNOLOGY

The total cost for the Hyperloop passenger transportation system as outlined for Los Angeles to San Francisco is less than \$6 billion. (TABLE I)

The cost to build in Tongren is expected to cost about \$1.5 billion which will be divided into two phases. The first phase for 10 km from city to Tongren Airport will cost \$290 million. The second phase is a 50 km route that connects the city to Mount Fanjing, one of the most popular tourist attractions[3]. Though China has the world’s largest highspeed rail network, they also try to develop a new supersonic transportation system like Hyperloop[4].

Table II  
Implementation Cost With Others[1,9,10]

Nowadays transportation system	Traction	Implementation	Max. speed (km/h)	Cost (million USD/mile)
High-speed rail	Electric power: wheel-rail friction	Already implemented	250-350	21
Maglev	Levitate by magnate, Electric power: wheel-rail friction	Already implemented	400-500	60
Hyperloop	Levitated by the magnet and air bearings, propel by linear motor	Under development	1200	1.5 billion USD, the whole cost of 36.2 miles

#### VI. WHAT MAKES THIS TRANSPORTATION TECHNOLOGY SO REALISTIC & SUSTAINABLE?

**A.** Hyperloop would be one only transport system that will have its own sustainable power producer system that can run the whole system. The whole top of the tube’s outer side will have solar panels to produce power from sunlight. That makes it a more sustainable transport system.

**B.** The system can transport passengers and goods at a very high speed one place to others. Currently, the speed 1200 km per hour, with this speed it can cover 561 km within 30 minutes. Compare to other transportation systems for high-

speed rail it takes 2 hours 38 minutes, by aircraft, it is covered in 1 hour 15 minutes. [1]

**C.** From table: 2, it is so apparent that the implementation cost is cheap than other modes of high-speed transport systems.

**D.** This transport system could be three modes of transportation like surface, underwater, underground as well. However, Association a unique underwater transport based on laying off the underwater tubes. As a result, the cargo can be transport with speed of sound. It would be a vast and revolutionary turning point in the whole shipping industry.

**E.** The system overcomes the limit on the speed of the land implemented transport in the most advanced modern transportation systems, such as magnetic levitation (maglev) train. A similar train in 2015 at the experimental site in japan reached a record of a maximum ground transportation speed of 603 km/h; This is half the acknowledged maximum speed of Hyperloop [6].

**F.** According to [1], the twin-tube Hyperloop route Los Angeles to San Francisco delivers passengers traffic in a volume of 840 people per hour, which consents to reach the route output capacity of 7.4 million people per year.

**G.** The new transport system can guarantee low costs in the design and the realization of the transport system. A small weight of transport capsules of several tons compared to multi-tonnage railroad train allows the use of significantly simpler bridges and transitions in the construction of Hyperloop roads. The total cost for passenger version hyperloop project from Los Angeles to San Francisco is \$ 6 billion, while for the alternative high-speed rail project, the US governments are ready to spend \$ 70 billion. Moreover, an interesting part of the project is a cheap ticket to travel long distances such as Los Angeles to San Francisco ticket will cost \$20, a ticket for travel on the high-speed rail will cost \$ 105.

**H.** Lower operating outlays, consuming 21 MW of energy, the passenger pod moves with an air cushion. The energy produces by solar cells which can produce 57 MW of energy.

**I.** The best part of the Hyperloop is independence from weather conditions, no problem caused at high-speed by small solid counter particles. For Subsonic transport, this is a big problem. This system is much quieter than the traditional high-speed transport system. Another part of this technology is ecological cleanliness due to using air, electricity generated by solar batteries.

**J.** Reliability and safety, The system safe from all the natural obstacles like floods, earthquakes, bad weather, against birds, animals and also different vehicles, pedestrians. As no physical interaction with cars and railways, pipelines, high voltage electric lines due to tube, this makes it safer and sounder traveling system. Path of motion, acceleration and deceleration processes are chosen

to take into account the people experience overloads not exceeding 1g. The fact is that the possible depressurization of the passenger capsule at the chosen pressure value in the tube leads to the instant death of passengers. To solve this problem each passenger should be dressed up with special suit like spacesuits [7]. However, if we do pressurize the passenger pod with air pressure, which pressure is suitable for human body then also, we can sort out this kind of issue. However, after using the system the decision can limit the flow of passengers. Therefore, some experts believe that initially, we need to build the system to observe what kind of further issue still we have related to safety and reliability and also for cargo transports (if we want after passenger transportation system).

## VII. FUTURE WORKS OF THIS NEW TECHNOLOGY

As this new technology is in under construction and visualization so here has a huge opportunity to develop as new mode to transportation which could dominate the all available transportation system(High Speed transportation system, Meglev transportation system). Worlds' most technologically develop nation(The USA, China, Germany) always have been trying to develop the new technology. So, this technology will come at Guizhou province in China which will be the next step to bring it in reality. After developing this technology it could reduce the travel time between long distance with affordable cost for travel.[12,13]

## VIII. CONCLUSION

Being a transportation system fast is not enough; it should be durable, sustainable and safer than others. It was outlined with safety in mind by Elon Musk, known as Hyperloop. Developing this project estimate costs \$6 billion from Los Angeles to San Francisco for only passenger travel. The cost of building technology in china \$1.5 billion only for 36.3 miles. Except US many come forward to develop this new technology like Dubai, China, And India, etc. It is a great privilege to the traveler which can save time and money at the same time.

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