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# Hyperloop Transportation Systems

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***Abstract: In the paper, we consider the features of the new revolutionary transportation technology (the Hyperloop technology) proposed in the USA and associated with the use of ultra-high-speed vacuum trains moving inside tubes with a reduced internal air pressure. In this study, the initial route, preliminary design, and logistics of the Hyperloop transportation system have been derived. In the paper, we examine the technical parameters of the tube and the capsule for the Hyperloop cargo systems and give some estimates for such technical and economic indicators as the cost of construction and the carrying capacity of the road. We discuss the question of what the Hyperloop technology can offer to solve serious transport problems of the modern world.***
***Keywords: Hyperloop;applications of hyperloop; low pressure;***

## I. INTRODUCTION

Transportation is an industry which is in constant flux: forced to keep up with the ever-growing human population while providing faster and cheaper methods of travel. There is a continuous interest to reduce travel times between distant human settlements while improving the overall efficiency of the transportation system. Proposed by ELON MUSK American business magnate, investor, and inventor in 2013. He is currently the CEO & CTO of SpaceX and CEO & Chief Product Architect of Tesla Motors.

A fast transit mode that guarantees travel at double the speed of a commercial aircraft, transporting travellers from Los Angeles to San Francisco in only 30 minutes. A Hyperloop would be "a raised, decreased pressure tube that contains pressurized capsules driven inside the tube by various linear electric motor."

This framework can accomplish a normal speed of 598 mph(962 km/h), and a best speed of 760 mph (1,220 km/h). Hyperloop comprises of a low pressure tube with containers that are transported at both low and high speeds all through the length of the tube.

The capsules are bolstered on a pad of air, including pressurized air and aerodynamic lift. The capsules are accelerated through a magnetic linear accelerator joined at different stations on the low-pressure tube with rotors contained in every capsule. Passengers may enter and exit Hyperloop at stations found either at the ends of the tube, or branches along the tube length.

## II. MOTIVATION

The general thought of trains or other transportation going through cleared tubes goes back over a century despite the fact that the atmospheric railway was never a commercial achievement. Elon Musk initially said that he was considering an idea for a "fifth method of transport", calling it the Hyperloop, in July 2013 at a Pando Daily event in Santa Monica, California.

The name Hyperloop was picked in light of the fact that it would go in a loop. It removes direct emission, noise, delay, climate concerns, and pilot or human mistake. The power required to run this framework will be provided by the solar panels fastened to the upper part of tube.

This speculative fast method of transportation would have the accompanying attributes: invulnerability to climate, impact free, double the speed of a plane, low power utilization and energy which can be stored for 24-hour operations.

## III. OBJECTIVE

Conventional modes of transportation:-
RAIL - relatively slow and expensive
ROAD - relatively slow
WATER - relatively slow and expensive
AIR - expensive
Hyperloop is the fifth mode generation of transportation. So we need to analyze Hyperloop as another method of transport that tries to change this worldview by being both quick and modest for individuals as well as merchandise.

 

## IV. LITERATURE SURVEY

### *A. [1] Hyperloop Transportation System: Analysis, Design, Control, and Implementation, IEEE 2017*

This study introduces a novel methodology based on an extensive mathematical analysis, performed from basic electromagnetic principles, with an optimized cost for a magnetic levitation Hyperloop system. This new approach uses both permanent magnets and electromagnets to levitate, propel, and control a pod.

The prototype consists of a test bench which consists of a track with solenoids and a pod with permanent magnets.

The controller system has an inverter circuit, the FPGA board, and the pod controller.

Inverter Simulation and Solenoid Simulation was performed correctly and the coils produce the force that was expected based on calculations.

### *B. [2] "Advantages of a New Hyperloop Transport Technology", IEEE 2017*

In the paper, the features of the new revolutionary transportation technology (the Hyperloop technology) proposed in the USA and associated with the use of ultra-high-speed vacuum trains moving inside tubes with a reduced internal air pressure are considered. The technical parameters of the tube and the capsule for the Hyperloop cargo systems are examined.

## V. DESIGN

### *A. The Hyperloop Consists of Four Major Components, Including*

1) Capsule
2) Tube
3) Propulsion
4) Route

### *B. Capsule*

Sealed capsules can carry about 28 travellers and moves along the inside of the tube. A bigger framework has additionally been measured that permits transport of 3 full-size vehicles along with travellers to travel in the capsule .The containers are bolstered by means of air bearings that work utilizing a compressed air reservoir and aerodynamic lift.

For movement at high speeds, the best power necessity is ordinarily to beat air resistance. Streamlined drag increments with the square of speed, and along these lines the power requirement increments with the cube of speed. The containers are isolated inside the tube by around 37 km on average during operation.

The capsules leave by and large at regular intervals of 2 minutes from Los Angeles or San Francisco (up to consistent interims.

Two versions of the Hyperloop capsules arc being considered: a passenger only version and a passenger plus vehicle version.

1) *Hyperloop Passenger Capsule:* Expecting a normal flight time of 2 minutes between containers, at least 28 travelers for every capsule are required to meet 840 travelers for every hour. It is conceivable to additionally expand the Hyperloop limit by diminishing the time between flights. The present pattern requires up to 40 capsules in movement amid surge hour. Six of which are at the terminals for loading and unloading of the travelers in around 5 minutes
2) *Hyperloop Passenger Plus Vehicle Capsule:* The traveler in addition to the vehicle version of the Hyperloop will depart as frequently as the traveler, however will accommodate 3 vehicles in addition to the travelers. All subsystems talked about in the accompanying segments are highlighted on the two cases.For travel at high speeds, the greatest power requirement is normally to overcome air resistance. Aerodynamic drag increases with the square of speed, and thus the power requirement increases with the cube of speed. For example, to travel twice as fast a vehicle must overcome four times the aerodynamic resistance, and input eight times the power.


 

Figure: Capsule of a Hyperloop

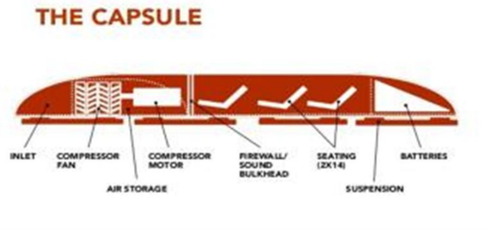


Figure: Hyperloop passenger capsule subsystem notional locations

### *C. Tube*

The tube is made of steel. Two tubes will be welded together in a side by side configuration to allow the capsules to travel both directions.

Pylons are placed every 100 ft (30 m) to support the tube. Solar arrays will cover the top of the tubes in order to provide power to the system. Tubes are made by the new material “VIBRANIUM”.

The Hyperloop travel journey will feel very smooth since the capsule will be guided directly on the inner surface of the tube via the use of air bearings and suspension; this also prevents the need for costly tracks. The capsule will bank off the walls and incorporate a control framework for smooth returns to nominal capsule location from banking also. Some particular areas of the tube will consolidate the stationary engine component (stator) which will locally direct and accelerate (or decelerate) the capsule. Between linear engine stations, the capsule will glide with little drag by means of air bearings.


Figure: Design of Hyperloop tube

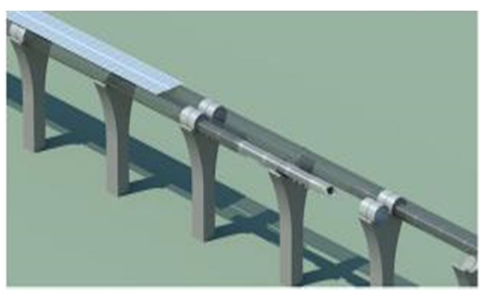

Figure : Hyperloop capsule in tube cutaway with attached solar arrays.

### *D. Propulsion*

Linear accelerators are developed along the length of the tube at different areas to accelerate the container.

Stators are situated on the containers by means of the linear acceleration.

Rotors are situated on the containers to transfer momentum to the capsules by means of the linear accelerators.

1) *Hyperloop Passenger Capsule :* The general propulsion framework weight connected to the capsule is expected upon to be close to 2,900 lb (1,300 kg) including the help and crisis stopping mechanism. The general cost of the framework is focused to be close to $125,000. This brings the aggregate capsule weight close to 33,000 lb (15,000 kg) including traveler and baggage weight.
2) *Hyperloop Passenger Plus Vehicle Capsule :* The overall propulsion system weight attached to the capsule is expected to be near 3,500 lb (1,600 kg) including the support and emergency braking system. The overall cost of the system is targeted to be

 

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no more than $150,000. This brings the total capsule weight near 57,000 lb (26,000) kg including passenger, luggage, and vehicle weight.

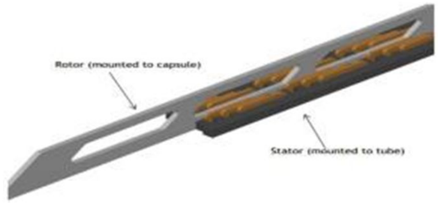


Figure: Rotor and stator 3D diagram

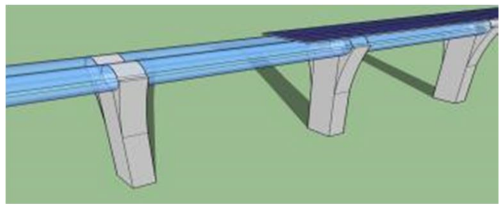

Figure: Graphical representation of Pylons of Hyperloop

*E. Route*

The Hyperloop route should be based on several considerations, including:

1) Keeping up the tube as nearly as conceivable to existing privileges of way.
2) Restricting the most extreme capsule speed to 760 mph (1,220 kph) for streamlined contemplations.
3) Restricting increasing speeds on the travelers to 0.5g.
4) Advancing areas of the straight engine tube segments driving the capsules.
5) Nearby land imperatives, including the area of urban zones, mountain ranges, stores, national parks, streets, railways, air terminals, and so forth. The course should regard existing structures.

There will be a station at Los Angeles and San Francisco. Several stations along the way will be possible with splits in the tube.
The majority of the route will follow I-5 and the tube will be constructed in the median.
In India, on February 22, 2018, Hyperloop One has entered into a MOU (Memorandum of Understanding) with Government of Maharashtra to build a Hyperloop transportation system between Mumbai and Pune that would reduce the travel time from current 180 minutes to just 20 minutes.


Figure: Proposed route between San Francisco and Los Angeles


Figure: Proposed route between Mumbai and Pune

## VI. APPLICATIONS

*A. The Hyperloop developers of the new system promise*

1) The system can transport people and cargo at a very high speed. Currently, the maximum speed of the Hyperloop is 1220 km / h. At this maximum speed, the capsule in the California project passes the distance at 561 km in 30 minutes. For comparison, the same distance a passenger aircraft overcomes in 1 hour 15 minutes, a high-speed train for 2 hours 38 minutes, and a car for 5 hours 30 minutes .
2) The system overcomes the restriction on the speed of the land transport available in the most advanced modern transportation systems, such as high-speed magnetic cushion train (maglev). 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 speed is half the declared maximum speed of the Hyperloop train.
3) Organization of a unique underwater transport based on the laying of the underwater tubes. N As a result, the marine traffic appears, moving with the speed of sound, unheard for the actual shipping.
4) The sufficiently high carrying capacity of the Hyperloop system. The twin-tube Hyperloop road Los Angeles-San Francisco provides passenger traffic in a volume of 840 people per hour, which allows reaching the road throughput capacity of 7.4 million inhabitants per year. The maximum carrying capacity of a freight line for the transport of standard 20-foot containers will be 2.1024 million TEU or 45.4750 million tons of cargo per year.
5) The system can guarantee low costs in the design and implementation 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. Underwater tubes can be used to pass water areas. So, as in the open sections, the main tubs lines are fixed on high pylons, the costs for alienating land for construction reduce. The planned costs for the passenger version of the Los Angeles-San Francisco Hyperloop project is $ 6 billion, while for the alternative high-speed railway project the US authorities are ready to spend $ 70 billion. In this case, when the planned payback period of the Hyperloop project in 20 years a ticket from Los Angeles to San Francisco will cost $20, and a ticket for travel on the high-speed rail will cost $ 105, i.e., five times more expensive
6) Low operating expenses. For the movement of passenger capsules in the tube using an air cushion, an energy of 21 MW is consumed. It is generating by solar batteries located on the outer surface of the tubes. The cells produce 57 MW, i.e. completely cover the cost of energy
7) Independence from weather conditions, no erosion caused at high speed by small solid counter particles. For the rapid land transport, this is a big problem. high-speed train during the traffic has the noise characteristics of the starting aircraft. Hyperloop is much quieter
8) Ecological cleanliness. The system uses air, electricity generated by solar batteries
9) Security The system protects against floods and earthquakes, against birds, animals, different vehicles, pedestrians. On all routes, one tube does not have counter-movements. There are no physical intersections with cars and railways, pipelines, high-voltage lines. Trajectories of motion, acceleration and deceleration processes are chosen to take into account that people experience overloads not exceeding 1g.

## VII. CONCLUSION

As the Hyperloop has number of advantages it will very helpful for transport public as well as goods in a very short time ( at top speed of 1220 kmph) and also in low cost.

It is new concept so there is some future work will be required for development of this project.

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