Study on Hyper Loop Transport Technology

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Abstract: The Hyper loop concept, pod speed competitions and current project developments have recently attracted much publicity. In this paper the transport technology of the vacuumed tube transport project Hyper loop is assessed through a system analysis of its principal aims, functional design, transport capacity and demand in comparison with existing commercial airlines, high-speed rail, and Maglev lines. First, the potential for high-speed long-distance travel demand for Hyper loop based on existing airline transport volumes between major airports in Germany on the one hand, and the proposed hyper loop link from Los Angeles to San Francisco in California on the other, is assessed in general terms. Second the technical feasibility of the proposed.

KEYWORDS: Hyper loop, Hyper loop Capsule, Hyper loop Passenger Capsule, Hyper loop Passenger Plus Vehicle Capsule, Compressor, Hyper loop Tubes, Maglev Trains

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I. INTRODUCTION

According to its principal protagonist, Elon Musk, Hyper loop aims to be a new mode of transport – a fifth mode after planes, trains, cars and boats – that should be safer, faster, lower cost, more convenient, immune to weather, sustainably self-powering, resistant to earthquakes, and not disruptive to those along the route (Musk 2013).

It is seen as an alternative state-wide mass transit system to flying or driving at distances < 1500 km, while the planned high-speed train is considered both slower, more expensive to operate (if unsubsidized) and less safe by two orders of magnitude than flying (Musk 2013).

The Hyper loop concept, promoted in 2013 and the following design competition in 2016, as well as the student team pod competitions on a 1.6 km long, 1.83 m diameter partial-vacuum purpose-built steel test tube track at Space in Hawthorne, California in 2017 and 2018 (Wikipedia 2018a), have stimulated considerable new research and development activities by students, scientists, consultants, and start-ups around the world. For example, in July 2018 and 2019, students at the Technical University Munich demonstrated that a maximum speed of 467 km/h is feasible in a partial vacuum tube with their wheel motor driven pod (240 kW, 70 kg) on the Space test tube track and won the speed-competition for the fourth time (TU Munich 2018, 2019).

1.1 What is hyper loop technology?

Hyper loop is an ultra-high-speed ground transportation system for passenger and cargo proposed as a concept by Elon Musk, CEO of Tesla and Space, in a white paper back in 2013.

The system consists of sealed and partially evacuated tubes, connecting mobility hubs in large metropolitan areas, and pressurized vehicles, usually called pods, which can move at very high speeds, thanks to contactless levitation and propulsion systems as well as to the low aerodynamic drag. With this system the door-to-door travel time on medium-range distances can be considerably reduced compared to current connections.

Moreover, with fully-electric operations the system aims at being climate-neutral.

Fig 1: **Hyper loop**

1.2 How does hyper loop work?

The Hyper loop system consists of sealed and partially evacuated tubes, connecting mobility hubs in large metropolitan areas, and pressurized vehicles, usually called pods, which can move at very high speeds, thanks to contactless levitation and propulsion systems as well as to the low aerodynamic drag.

II. TECHNOLOGY

The wheel-less, pressurized pods hurtling through a hyper loop are propelled by linear induction motors and axial compressors. With traditional wheels having been eradicated, the air bearings are designed to make the ride extremely smooth and quiet – analogous to travel by magnetic levitation. A further benefit is that being in sealed tubes. The pods are not subject to disruption by weather events, people or animals on the track or level crossings.

However, travelling at such high speeds has its drawbacks: to avoid inducing nausea in passengers, the pods would take three minutes to accelerate to top speed, while negotiating a 90-degree bend would have to be performed over a distance of six miles.

III. CONSTRUCTION

1. Tube

Hyper loop tubes make up a large part of the total hyper loop infrastructure. The tubes need to be strong, stiff, durable and airtight. Furthermore, the tube should be able to cope with all the external influences such as saline air, rain, heat and vandalism. Since the tubes make up such a big part of the hyper loop system cost (over 20%, **see** A Closer Look at Infrastructure Costs), it is desired to achieve these requirements for the lowest cost possible.

Steel has been nominated as the material for a hyper loop tube by the hyper loop community but without much consideration.

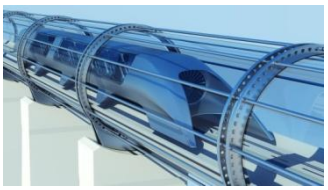

Fig 2**: hyper loop steel tube**

1. Capsule

Construction is underway for delivery and the official reveal will be in early 2018 at HTT's R&D center in Toulouse, France. The capsule will then be utilized in a commercial system that will also be announced soon. The capsule is 30 meters (98.5 feet) long, 2.7 meters (9 feet) wide. It weighs 20 tons, can hold 28-40 passenger and can reach speeds up to 760 mph.

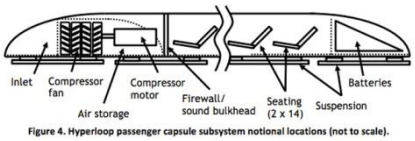

Fig 3: **Capsule**

2. Compressor

An onboard compressor in front of the pod will allow the collected column of air traveling in front of the pod to flow through the system without compromising the increasing velocities of the pod. A second function of the compressor would be to supply air to the air bearings that support the weight of the capsule throughout the passage.

Traditionally, axial compressors are coupled with a complimentary turbine at the exhaust that provides mechanical power to the compressor. In the hyper loop, the proposed compressor arrangement will be driven by electric motors instead of turbines.

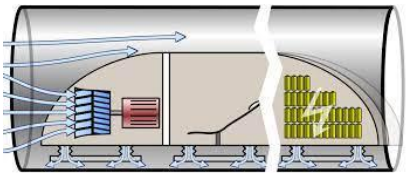

Fig 4: **Compresor**

3. suspension

Electrodynamics suspension (EDS) is based on repulsive electromagnetic forces. A conducting guide way/track will be required. The hyper loop pod is equipped with Halbach arrays on the bottom. Halbach arrays are magnets in a special configuration, focusing the magnetic field towards the track.

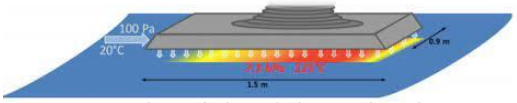

Fig 5: **Suspension**

4. Propulsions

The hyper loop concept is a vacuum tube train design where capsules will accelerate gradually via electric propulsion through a low-pressure tube, float above the track using magnetic levitation, and then glide for long distances at speeds more than 1220kph due to ultra-low aerodynamic drag.

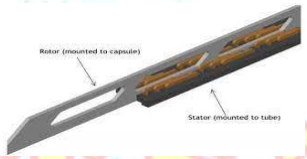

Fig 6: **Propulsions**

IV. HOW DOES THE HYPERLOOP GO SO FAST

A hyper loop is able to reach extreme speeds because it addresses one of the most basic rules of physics—friction slows things down.

Hyper loop designs rely on creating a low-friction environment within a tunnel or tube. Individual pods seating a small group of people could then travel at extreme speeds through the tubes.

The hyper loop travels via an efficient electric motor, and friction is reduced in two ways

Depressurized tunnels create a near-vacuum environment where almost all of the air has been sucked out. This creates an environment where extremely high speeds are possible because there's minimal aerodynamic drag or wind resistance.

Magnetic levitation (maglev) causes each pod to hover. This removed the ground friction of wheels or tires that occurs in other modes of ground transportation. This technology is already being used in high-speed bullet trains. In the image above, the magnets in red are for levitation and propulsion. The magnets in blue are for horizontal stabilization.

V. HOW DOES THE HYPER LOOP WORK?

The Hyper loop system consists of sealed and partially evacuated tubes, connecting mobility hubs in large metropolitan areas, and pressurized vehicles, usually called pods, which can move at very high speeds, thanks to contactless levitation and propulsion systems as well as to the low aerodynamic drag**.**

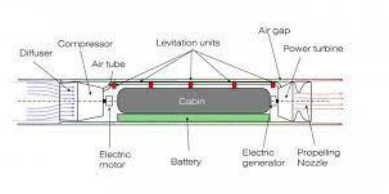

Fig 7**: Transportation system**

VI. HYPERLOOP DESIGN

- Enclosed chambers can carry travelers or freight.
- Low-pressure tubes reduce aerodynamic drag.
- Magnetic levitation (maglev) keeps each pod hovering above the track while it's in transit.
- Electric. Propulsion moves each pod through the tube.

VII. CONCLUSION

- A high speed transportation system known as hyper loop has been developed in this document.
- High speed of transportation coupled with low capital and maintenance cost give Hyper loop a leading edge.
- More expansion on the control mechanism for Hyper loop capsules, including attitude thruster or control moment gyros.
- Trades comparing the costs and benefits of hyper loop with more conventional magnetic levitation systems.

Detailed station designs with loading and unloading of passenger and passenger plus vehicle versions of the Hyper loop capsules.

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