LINKÖPING UNIVERSITY

Expert conference: The Hyperloop

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1 Introduction

Is traveling from New York city to Washington D.C. in 30 minutes just an imagination or slowly becoming a reality? Hyperloop is the new trend based on a concept from Elon Musk who wants to make the development as an opensource project. "How does this technology work and what is standing behind Hyperloop will be explained in the next paragraph." [1] Hyperloop is based on moving capsule approaching to subsonic speed which is propelled electromagnetically in close long tubes. Musk's theory is that pods will be held in the air on a cushion of the air. Similar to the work of other companies with the idea of "MAGLEV". To managae the air cushion underneath the capsules strong electro-magnets are needed. [2]
The HL (Hyperloop) belongs to the group of HSR (High speed rail) and APT (Air passenger transport). One of the biggest issues at higher velocities is the parasite drag. Therefore the aerodynamic of the train is getting really important. The difference between any usual train and the HL will be, that the HL is going through a pipe, which is almost evacuated. This means there will be a certain under pressure, to reduce the influence of the air pressure. The tube is composed of 3 parts. In the station is normal atmospheric pressure. When the capsule moves to the second part the hermetic doors close the area and the special ultra-high vacuum pumps set up the pressure to the values about 10-8 Torr. (Atmospheric pressure is at the level 760 Torr = 1.013×10^5 Pa). The last chamber is 'departing' chamber with usual air pressure. [3]
The idea of hyperloop predicts low travel costs connected with high energy efficiency of the ride as well as cheap source of energy.[3] The idea to provide the needed power, is to cover the pipes with solar-panels.

2 Pros and Cons Hyperloop

The biggest advantage will be the time saving. If you can travel with more than 1000 km/h with almost no acceleration time, distances are no problem anymore. You also won't need long check-in times and security checks anymore. It will also fit in the necessary setup

Fig. 1 . Real capsule of Virgin hyperloop-one company which was already tested in Nevada - United States of America. [4]

for the city of the future. Which will look totally different to nowadays cities. There will be a time, when you can also get into the city by public transport or self-driven cars. So, you can leave the hyperloop at stations all around the city and get to your office by self-driving or -flying cabs. There will be no traffic jams anymore and the cities getting free of all the exhausts. It also fits in the future transport systems, things getting faster and you can also stuff the pipes with transport wagons.
The supply of the needed electrical power will be managed by covering all the pipes with solar panels there will be more power generated then needed for the hyperloop, so you will gain power and you won't increase the total power consumption. Another advantage will be that the tracks are also protected against weather, birds and other objects due to the pipe. And the automation of this system will reduce the risk of human failures. Last but not least if any failures occur, the wagon will stop in the worst case, but it won't fall of the sky for example. [5],[6]

On the other side when the wagon stops somewhere in the pipe, how do you get the people out? The easy part will be to get rid of the vacuum but you are still far away from any official exit to get the people out. Also, it will be super expensive to setup the infrastructure with the pipes and the special designed stations. Also, the stations should be in the center of the city otherwise you will lose again a lot of time to get into the center by public transport or cabs. On top building ground in the city centers is also super expensive so there will be another problem to install the needed stations. And there are still no exact values

about the amount of energy this transportation system will need. If it goes by night, there won't be a any sun which can take care for the energy consumption. So, you must think also about energy saving systems.
Another big issue will be the security. The track they are building in California right now is in the middle of an earthquake hot spot. There are also plans to build it next to highways – what's about car/truck crashes into one of the pillars. And Terrorist can attack now the whole track. And if there is an accident with a speed of 1000 km/h that will do a lot of damage, to the environment as well as to the track itself. So, if the track isn't repaired it can't be used.
A fundamental basic point for the construction will be that due to the high speed there can't be any sharp curves or abrupt changes of height. Finally, this technology was already introduced in the 70's: Maglev trains. China has been the country who wants to include this technology into its infrastructure, but it failed on the already established infrastructure and the also upcoming fast trains. [5], [6]

3 Comparison of Hyperloop with other ways of transports

3.1 Hyperloop versus regional aircraft

Nowadays, planned routes for the Hyperloop only take a narrow segment of the range in which commercial aircraft operate. Since, the distance of the routes varies up to 1100 km it is directly a competitor to the regional jets. [7] As can be seen in the table the expected time savings are considerable, and they would be even higher if we compute the needed time for the boarding, security checks at airports and the consumed time to go to the airport (far away from the city center in some cases). The size of the tubes is similar to the size of the cabin of a regional airliner, with a capacity of 28 people per wagon, then for achieving the same capacity as an regional jet (for example, the ATR-600 can load up to 78 passengers[8])several wagons would be needed. Regarding the performance, maximum accelerations are double or triple the ones that take place during aircraft operation and the maximum cruise speeds (1200 km/h and 0.85 Mach) are considerably higher then airplanes. The combination of these two factors explain the significant amount of time reduction. On one hand, the cost of a line is quite expensive compared to the infrastructure of air traffic, however there is little man control and surveillance and security is hoped to be improved for this kind of travel.

Origin	Dest.	t_Hyp (min)	t_jet (min)
St.Francisco	Los Angeles	35	75
Toronto	Montreal	39	70
Helsinki	Estocolmo	30	55
Mumbai	Chennai	63	110

Table 1. Examples of actual planned routes duration.

3.2 Hyperloop versus bullet trains

The second set of comparison is done with the bullet trains, one of the best examples would be the shanghai maglev train of china. Bullet trains are one of the fastest on ground mode of long range transport present today.[9]
Bullet trains can reach speeds of almost 500 kmph and are already functional in many parts of the world. The main reason of comparing bullet trains to hyperloop is the technology both the vehicles use. On the basic principle both of the mode of transport use maglev technology for movement.[10]
The major difference is that in case of hyperloop a vacuum is created in a tube in order to mimic flying at high altitude to reduce drag. This creates a very energy efficient system.
The table put up show the major performance parameters between the hyperloop and the bullets train.

Component	Hyperloop	Bullet Train
Speed	1000 kmph	500 kmph
Technology	Maglev+near vaccume tube	Maglev
Cost of setting up	9 billion	1.2 billion
Cost per pax for 50 kms	around 2 dollars	6 dollars
Status	Experimental stage	Functional

Table 2. Hyperloop vs. Bullet train comparison.

From the table when we consider the speed, the hyperloop in its test stages had reached 387 kmph but it is expected to reach speeds of 1000kmph which is almost double the speed that the bullet train can attain, this means the same distance is covered in half the time, more number of trips two and fro and more passengers can be transported.
Contrary to the above point the cost of setting up of the hyperloop is very high compared to the bullet

trains but the cost per passenger is low which makes it a favorable mode of transportation for a common man. Also, other than the performance parameters when environmental impact is taken into account, the hyperloop creates negligible emissions and has a much smaller civil engineering footprint when compared to bullet trains. The design of the hyperloop makes it immune to bad weather and uncertain environmental conditions like earthquake etc.

Hence comparing both, It is clear that hyperloop has an upper hand. But the fact that hyperloop is still in experimental stages where as the bullet trains are already functional shows there is a large margin for analyzing and further improvement for hyperloop.

4 Conclusion

Hyperloop is the technology of the future coming to life in present times. With its high speed performance and time saving travel, it is a much needed mode of transport in today's growing world. Also considering the point that this technology does not consume lot of energy and that the required energy will be derived from solar panels, this makes hyperloop a sustainable mode of transportation. But it is also very ambition project, to include such systems in the old cities over the world will get difficult and more expensive then planed.

Comparison of hyperloop with HSR (High speed rail) and APT (Air passenger transport) shows promising results for hyperloop.

To answer the question if hyperloop would be a success or a hyperflop and would not reach the expectation lies in the test of time. As hyperloop is still in the experimental stages this statement can be determined after it comes into operation. As engineers, new and innovative projects should always be appreciated and intrigue us to take it a notch higher. Keeping this in mind, hyperloop is definitely one of the most anticipated projects to come into action and shows a positive trail.

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