HYPERLOOP: A FIFTH MODE OF TRANSPORTATION

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In USA was presented the project of new transport system intended for superfast travel between large cities — Hyperloop. The project belongs to businessman Elon Musk who has earlier created payment PayPal system and the Space X company, the first one among non-state organizations which successfully delivered the spaceship to an orbit. Besides, Musk is the general director of Tesla Motors, a company that producers luxury electric cars.

It was earlier known the idea of Hyperloop, however the detailed presentation of the project containing technical specifications and an economic justification the day before was for the first time published. So, Elon Musk's new fantastic project represents the transport system consisting of moving on tubes with strongly rarefied air of aluminum capsules.

The project was named — Elon Musk's Hyperloop (Figure 1) [1].

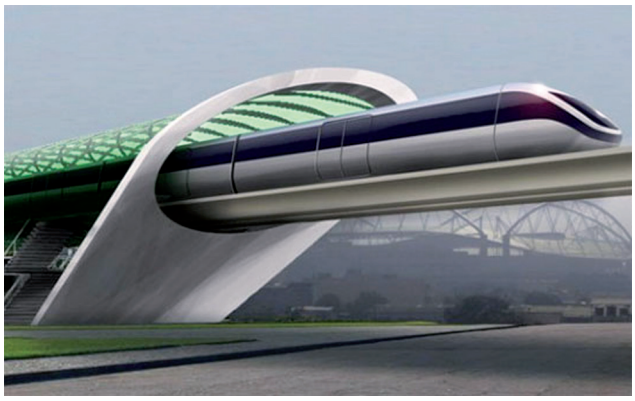

Figure. 1. Elon Musk's Hyperloop

In September, 2012 E. Musk compared his project (which is at a development stage) with land "Concorde": for comparison its speed will exceed the cruiser speed of "Boeing-787" on 200 km/h. Hyperloop is something average between "Concorde" and electromagnetic railgun, thus it doesn't demand rails.

According to the principle work of Hyperloop, by the words of E. Musk, it is similar to the pneumatic train Aeromovel. Aeromovel doesn't allocate harmful blowouts, almost doesn't rustle and is capable to disperse to the speed of 80 km/h that does it an ideal city and suburban transport. We will note that the train Aeromovel is successfully operated in Porto Alegre (Brazil), and also in Jakarta (Indonesia).

Technically Hyperloop — the electromagnetic gun, "shooting" a shuttle: the running electromagnetic impulse disperses a capsule with people to the subsound speed (about 330 m/s), supports it on the most part of a way then also makes braking (the kinetic energy transformed in electric, stocks up). In turn, the shuttle facilitates dispersal and sliding, soaking up air nasal part (a loss minus on front resistance) and throwing out it through nozzles of metal "skis" under which the air layer is formed (Figure 3).

A new high speed mode of transport is desired between Los Angeles and San Francisco; however, the proposed California High Speed Rail does not reduce current trip times or reduce costs relative to existing modes of transport. This preliminary design study proposes a new mode of high speed transport that reduces both the travel time and travel cost between Los Angeles and San Francisco. Options are also included to increase the transportation system to other major population centers across California. It is also worth noting the energy cost of this system is less than any currently existing mode of transport (Figure 4). The only system that comes close to matching the low energy requirements of Hyperloop is the fully electric Tesla Model S.

The aerodynamic power requirements at 700 mph (1,130 kph) is around only 134 hp (100 kW) with a drag force of only 72 lbf (320 N), or about the same force as the weight of one oversized checked bag at the airport. New technologies which turn

INFORMATION

The vehicle is driven by a pneumatic propulsion system which converts electrical power into air flow and transmits thrust directly to the vehicle without gears or intervening electric circuits (Figure. 2). Stationary electrical blowers, located close to the passenger stations produce the necessary pressurized air, which is generated according to the desired vehicle acceleration rate and speed. The elevated guideway can accommodate gradients up to 12%, and tight horizontal curves with radii as low as 25 meters.

Figure 2. Propulsion system of Aeromovel

AEROMOVEL with its exclusive right-of-way and comparatively short headways is designed to carry up to 10,000 passengers per hour per direction [2]. The light weight of AEROMOVEL vehicles ensures that energy is not wasted moving heavy deadweight (empty vehicles); the extreme simplicity and high reliability of AEROMOVEL results in reduced maintenance requirements. Air propulsion eliminates the problems of heavy rail traction; wear on wheels and tracks is reduced to a minimum. The electric motors on the air blowers are sturdy, completely independent units. Because the purpose of these motors is to pump air, not drive the vehicle, maintenance requirements are minimal. Operation is fully automatic. No drivers are required on-board. High reliability automation systems are used for protection, control and supervision of the vehicle operation.

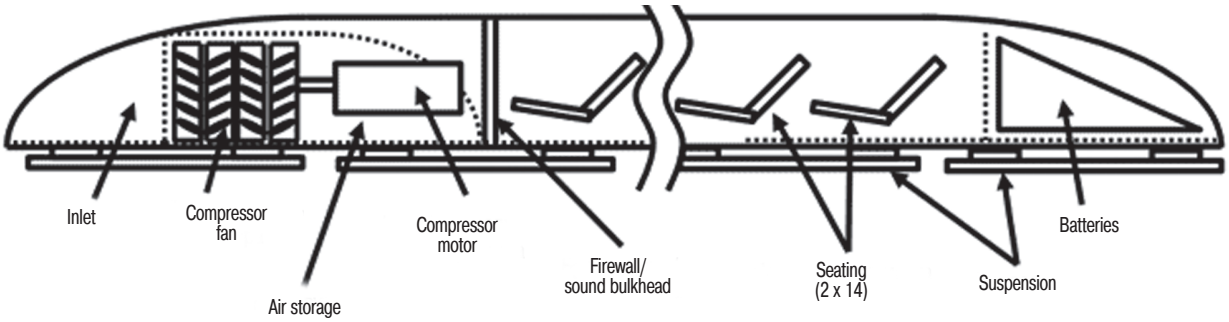

Figure 3. Hyperloop passenger capsule

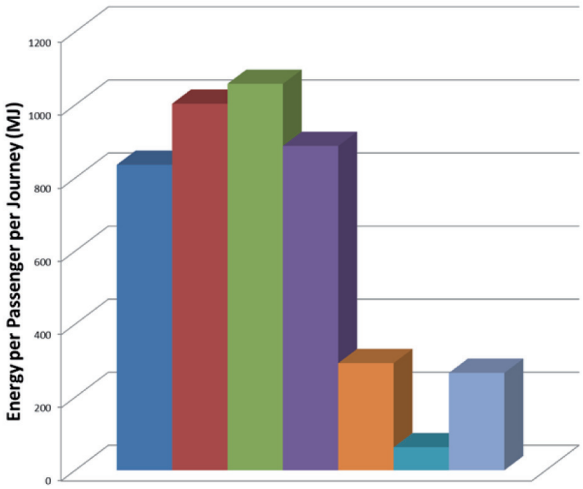

Figure 4. Comparison of energy expenses on one passenger for a trip to Hyperloop and other means of transport

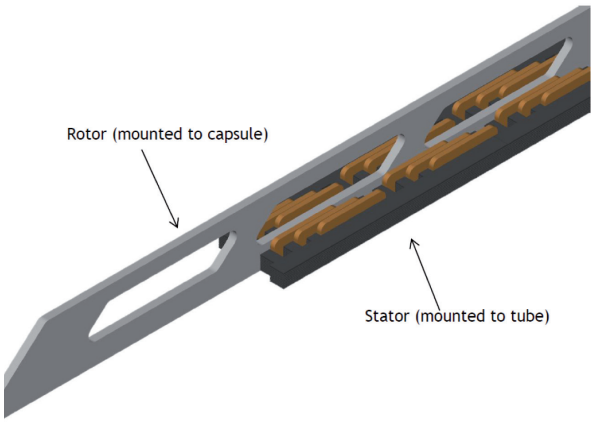

Figure 5. Rotor and stator 3D diagram

Hyperloop into absolutely new type of transport are applied to achievement of these characteristics.

Dispersal of the train will be made by means of a magnetic field, thus stators are planned to place in a tunnel, and rotors — on a passenger capsule car (Figure 5).

The geometry of the tube depends on the choice of either the passenger version of Hyperloop or the passenger plus vehicles version of Hyperloop.

In either case, if the speed of the air passing through the gaps accelerates to supersonic velocities, then shock waves form. These waves limit how much air can actually get out of the way of the capsule, building up a column of air in front of its nose and increasing drag until the air pressure builds up significantly in front of the capsule. With the increased drag and additional mass of air to push, the power requirements for the capsule increase significantly. It is therefore very important to avoid shock wave

formation around the capsule by careful selecting of the capsule/tube area ratio. This ensures sufficient mass air flow around and through the capsule at all operating speeds. Any air that cannot pass around the annulus between the capsule and tube is bypassed using the onboard compressor in each capsule (Figure 6).

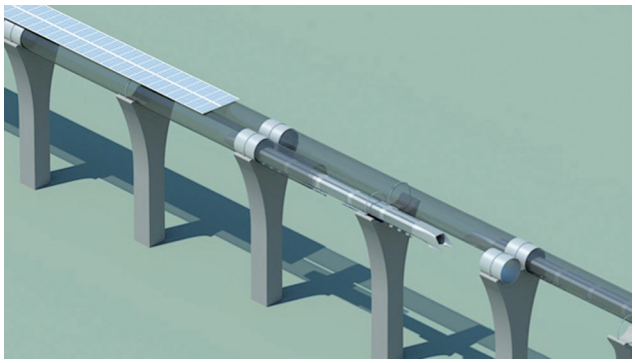

Figure. 6. Hyperloop capsule in tube cutaway with attached solar arrays

Two versions of the Hyperloop capsules are being considered: a passenger only version and a passenger plus vehicle version. Assuming an average departure time of 2 minutes between capsules, a minimum of 28 passengers per capsule are required to meet 840 passengers per hour (Los Angeles — San Francisco). The distance in 550 km the train will be able to overcome in only 30 minutes., i. e. quicker, than a modern airliner, especially considering time of preparation of the plane to a departure and its dependence on weather conditions (Figure 7).

Figure 7. Hyperloop tube stretching from Los Angeles to San Francisco

The Hyperloop project was developed as an alternative to the project of the English California High Speed Rail Authority, CHSRA, the predicted which maximum speed of 350 km/h. The estimated cost of the Hyperloop line Los Angeles — San Francisco is 6 billion dollars (the truth, it for 10% exceeds the cost of a similar site of CHSRA).

In the theory the Hyperloop system is safer than planes and trains. "I do not want to say "never", but the collapse of the system seems to me highly unlikely" — said author of the project E. Musk. Safety of the train is ensured by a number of "clever" systems which stop a passenger capsule in case of dangerous depressurization of salon or a tunnel. Even if the external power supply will completely be disconnected, the fan in a nose of the train will continue work and will provide airbag maintenance as it eats from the accumulators located in the tail of the train. Perhaps, heavy fan in a nose of the train and the storage battery in the tail are the only disputed issue: the passenger compartment in case of blow can appear between two fires. In case of danger Hyperloop will automatically stop, and each shuttle will provide the means of individual salvation, including oxygen masks for passengers.

HYPERLOOP TECHNOLOGIES

In Hyperloop uses technology that the company Tesla Motors practices in electric cars Tesla S. "Linear induction motors have long existed. They were invented by Nikola Tesla", — said E. Musk. To power the system will use solar panels.

The prototype Hyperloop Musk build their own. "I think it will help the project. In addition, for the construction of the sample need to get smaller government approvals," — said E. Musk. Theoretically, it could be established in one year. However, according to a billionaire on his list of priorities now occupies a commanding position not Hyperloop, and by Tesla and Space X.

According to the developers, the implementation of such a system would cost significantly less. For comparison, the high-speed rail project cost messages authorities proposed California reaches $ 70 billion, and the cost of construction line Moscow — Kazan (811 km) for high-speed passenger trains of the RZhD is estimated at 928 billion rubl. ($ 28 billion). This figure, unlike E. Muska's calculations for Hyperloop, does not include the costs of acquisition of a rolling stock.

The overall cost of the passenger capsule is targeted to be no more than $ 255,000, and its comfort is comparable with airliner interior (Figure 8). Overall interior weight is expected to be near 5,500 lb (2,500 kg) including the seats, restraint systems, interior and door panels, luggage compartments, and entertainment displays (Figure 9).

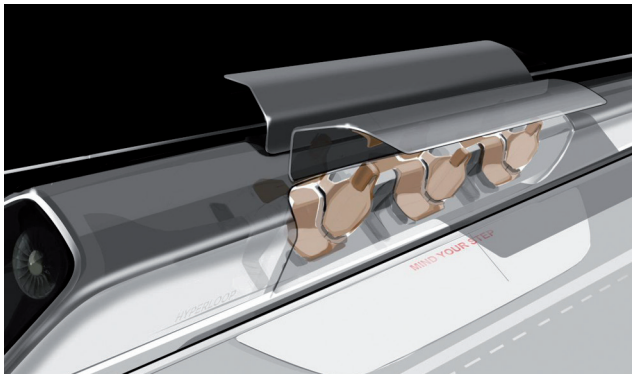

Figure 8. Hyperloop passenger capsule version with doors open at the station

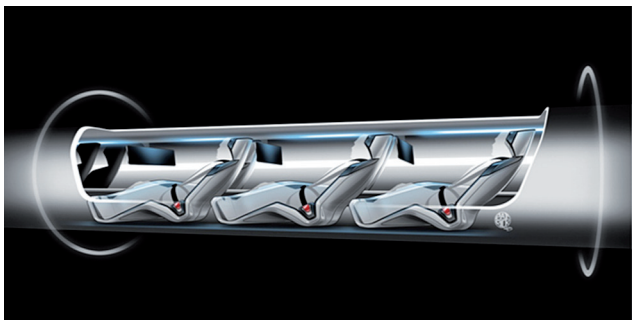

Figure 9. Hyperloop passenger capsule version cutaway with passengers onboard

The Hyperloop passenger plus vehicle capsule overall interior weight is expected to be near 6,000 lb (2,700 kg) including the seats, restraint systems, interior and door panels, luggage compartments, and entertainment displays. The overall cost of the interior components is targeted to be no more than $185,000. that is lower than the passenger only capsule interior as vehicles do not require the same level of comfort as passengers.

The price of the ticket of Hyperloop will make according to assumptions of the inventor only 20 dollars, i. e. about 3,5 cents for km. For comparison: "Sapsan" ticket from Moscow to St. Petersburg stands up today about 180 dollars, i. e. 25 cents for km of a way or is more than seven times more expensive.

STATIONS FOR HYPERLOOP

And a little bit about the stations for Hyperloop. All the stations are intended to be minimalist but practical with a boarding process and layout much simpler than airports.

Due to the short travel time and frequent departures, it is envisaged that there will be a continual flow of passengers, in contrast to the pulsed situation at airports which leads to lines and delays. Safety and security are paramount, and so security checks will still be made in a similar fashion as TSA does for the airport. The process could be greatly streamlined to reduce wait time and maintain a more continuous passenger flow.

All ticketing and baggage tracking will be handled electronically, negating the need for printing boarding passes and luggage labels. Travel time is very short, the main usage is more for commuting than for vacations. There would be a luggage limit of 2 bags per person, for no more than 110 lb (50 kg) in total. Luggage would be stowed in a separate compartment at the rear of the capsule. This luggage compartment can be removed from the capsule, so that the process of stowing and retrieving luggage can be undertaken separately from embarking or disembarking the capsule's passenger cabin.

Note that loading and unloading would occur in parallel with up to three capsules at a given station at any time. The expected cost for each station is around $125 million for a total of $ 250 million USD initially.

RAILWAY TRACKS FOR HYPERLOOP

As to design of railway tracks opinions of the authors were divided.

One group of engineers plans to create the latest system a monorails which founded on the principles of the Lofstrom project (Figure 10). In this case, the movement of trains will be carried out by electromagnetic effects "sole" of structure with ways [3]. The similar method will allow an electric train to reach the speeds proportional to speed of movement of military fighter aircrafts, and to send to space 4 million people a year. The first Startram can already appear in 20 years [4].

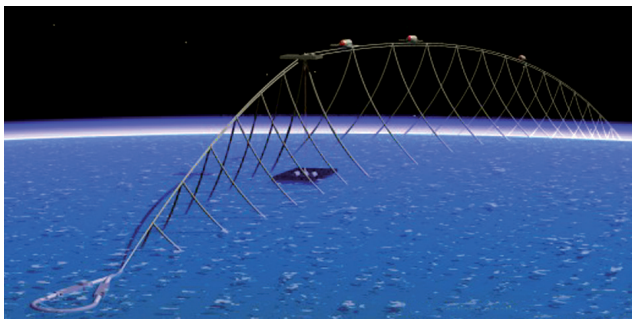

Figure 10. Railway tracks based on Lofstrom

The Startram orbital launch system would transport passengers and cargo into space in a magnetic levitation (maglev) train.

Like a train, the Startram track can follow the surface of the Earth for most of this length. Side forces associated with the curvature of the surface can be accommodated by the design, but not the drag and sonic shock waves of a craft traveling at hypersonic velocity at sea level — the spacecraft and launching track would be torn to shreds [5].

The cargo Startram version, according to the estimates of J. Powell, will cost 20 billion dollars, reports Daily Mail.

But in the future train will pay for itself. According to the author of the project, the cost of running one kilogram of cargo into orbit will be less than $ 40. With powerful electromagnets with a cargo capsule will depart from the tube at a speed of 8 km/s (Figure 11). The use of rockets is very expensive, because it absorbs too much fuel: 800 kg of fuel per 1 kg own weight and cargo.

However this idea has a mass of critics. "Construction of the space elevator possibly only in the theory therefore even by 2050 and nobody will do it". It was a common opinion of experts of the major scientific institutions space industry: Space Research Institute, The Russian Federal Space Agency,

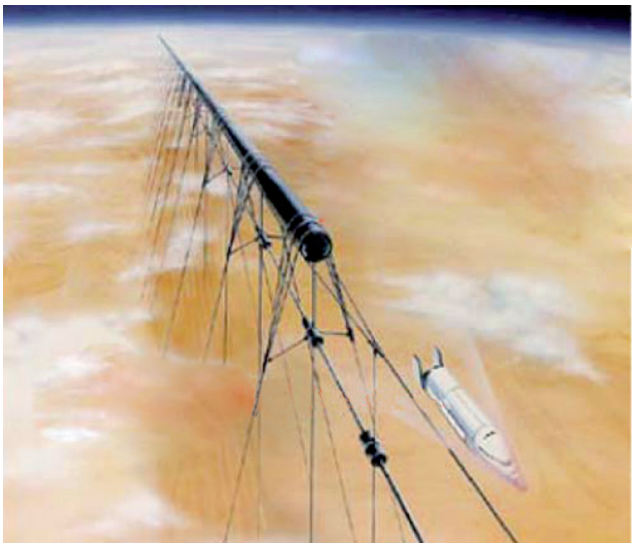

Figure 11. The Startram orbital launch system

Korolyov Rocket and Space Corporation Energia. Experts say that the biggest problem is a cable. Nanotubes suitable for its establishment, but they themselves desired length yet.

The expert of a space cluster of the Innovative center "Skolkovo", the worker of science of the Russian Federation V. Burdakov explains that the idea is initially considered incorrectly, as the elevator — it not a cable, but elevator mine with a cabin inside. And in space also it will be necessary to build mine, only is 10 times wider. Thus, the cable is not thrown in the sky, and the pipe is built. Thereof there is a complex dynamic problem of influence of external destroying factors. Theoretically this project is submitted on Figure 12.

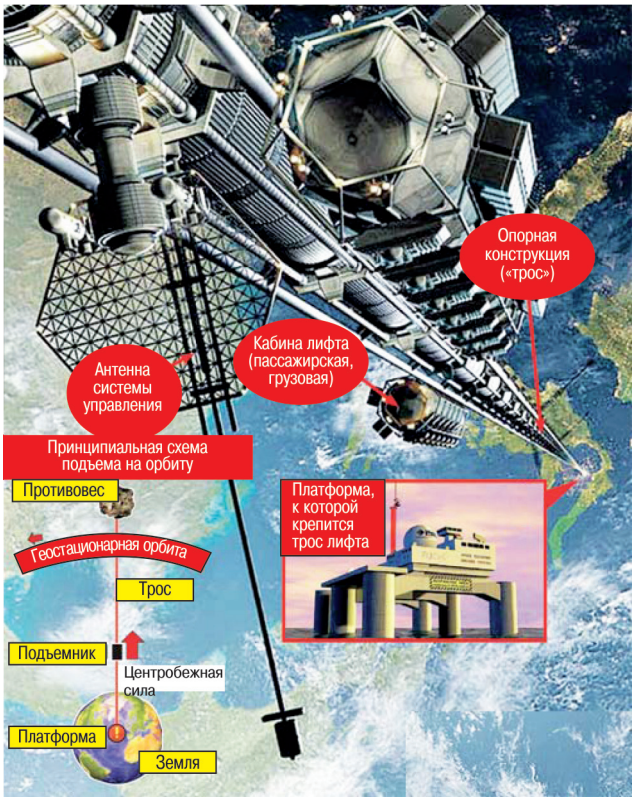

Figure 12. Project Startram in theory

The second group of engineers suggests to start up structures on the special vacuum tunnels deprived of terrestrial gravitation (Figure 13). The similar method will allow to reach improbable speeds, however will demand still big power expenses.

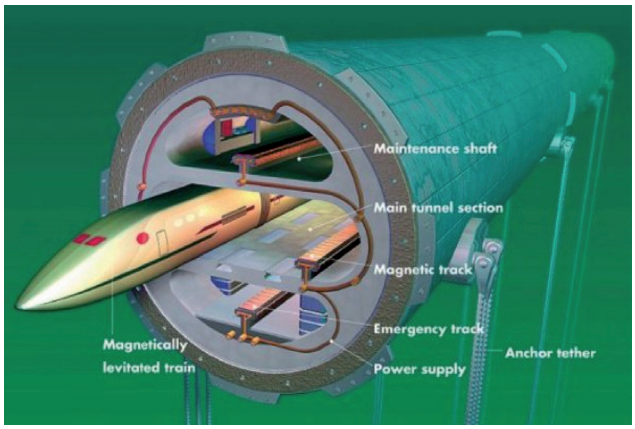

Figure 13. Vacuum tunnel for Elon Musk's Hyperloop

Originally trains of the Elon Musk's project is planned to use only as freight transportation. The first tests of Elon Musk's Hyperloop are planned for 2017. Now scientists solve a problem of atmospheric overloads at movement and a problem of energy consumption. In case of successful implementation of the project Elon Musk's Hyperloop will become "the fifth mode of transport" and the fastest in the world.

The ambitious project of absolutely new type of high-speed transport can connect some large cities of the world much more effectively, than the high-speed railroads.

As E. Powell said, "We are human beings at the beginning of a new era. Either we will become true space people, or we will remain in a trap on the overpopulated planet captured by fight against constantly being reduced resources".

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