

# Innovation in Transport as the Answer to Contemporary Communication Problems

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New technologies and innovations can significantly contribute to removing or reducing problems related to modern transport.

Hyperloop is an innovative mode of transport whose task is to move people or loads at very high speed, based on the concept of sustainable transport. Due to the benefits it brings - environmentally friendly, fast, self-sufficient in terms of energy, ensuring a high level of mobility, it is an interesting option that in the future can replace the existing means of transport.

The aim of this article is to present the theoretical and empirical aspect of the innovative mode of transport - Hyperloop, as an attractive alternative which in the future can replace the existing branches of transport.

The work consists of a theoretical and empirical part. The theoretical part of the work presents selected contemporary transport problems, the concept of innovations in transport and the mode of transport - Hyperloop. The empirical part of the work presents a proposal to connect selected European cities and estimate the time of traveling between them using Hyperloop.

**Keywords:** innovations in transport, new technologies, hyperloop, contemporary transport problems.

## 1. INTRODUCTION

Transport is an area of economy that is characterized by dynamic development. The reasons for the development of transport are connected, among others, with the growing requirements and awareness of consumers and the use of new technologies and innovations, that create new opportunities for modifying and introducing non-stereotypical solutions to the existing transport system.

Modern transport has a significant, positive and negative impact on the environment in which it operates. Transport problems include: generated costs, growing transport needs of the society, and negative impact on the natural environment. Some of the barriers that affect modern transport can be removed or significantly reduced by innovative means of transport.

One of the innovative means of transport is Hyperloop - an alternative that combines the benefits of travel by train and plane, while avoiding their drawbacks [Sultana S., Weber J., p. 138]. Taking into account the forecasts of

MarketsandMarkets, in 2022 the Hyperloop technology market will be valued at USD 1.35 billion, while by 2026 it will reach USD 6.34 billion (with CAGR 47.20% in 2022-2026) [MarketsandMarkets, online].

The aim of this article is to present the theoretical and empirical aspect of the innovative mode of transport - Hyperloop, as an attractive alternative, which in the future can replace the existing branches of transport. The theoretical part of the work presents selected contemporary transport problems, the concept of innovations in transport and the mode of transport - Hyperloop. The empirical part of the work presents a proposal to connect selected European cities and estimate in optimistic and pessimistic variant the time of traveling between them using Hyperloop. The subject of the work was taken due to its current and attractive character.

## 2. MODERN TRANSPORT PROBLEMS

Transport is an element of the economy characterized by dynamic development and one of the most important areas of modern life. It is associated with a number of positive and negative effects.

Transport needs are the reporting by the economy and society of potential and separate from others the need, to move people, cargo and information at a given time and for a given distance [Tylicki H., Gorzelańczyk P., p. 3832]. The needs for moving people and / or goods are constantly increasing, which generates an increasing number of transports as well as vehicles, which results in costs. The costs can be considered due to their internal and external nature. Internal costs can be defined as those that are borne directly by transport users and carriers [Ledzian P., p. 21]. The external costs are all costs of consuming the means used to create the transport service, which are not borne by the buyer and the producer of the service, but by the third party, that is the general public [Pająk L., online]. These include, above all, costs related to the negative impact of transport activities on the environment and human life. Analysing data relating to the generation of external costs by all branches of transport, the highest share in all categories is covered by road transport - from 85 to 97% of external costs [Mendyk E., pp. 270-271]. The main categories of external costs are, among others, [Urbanyi-Popiołek I., p. 23]:

- costs related to the use of transport infrastructure;
- costs of transport congestion (reflecting the time losses of transport users due to the longer transport time, congestion, increased fuel costs, etc.);
- costs related to noise (costs of treatment of physical and mental ailments as well as costs related to the negative impact on the environment);
- costs related to transport accidents (uncovered accident costs related to, for example, pain and suffering);
- costs related to air pollution and the environment as a whole (caused by the impact of fumes on human health, the natural environment).

Modern transport faces many problems, including, among others, growing transport needs, generated internal and external costs. Some of the

barriers affecting modern transport can be overcome or significantly reduced by the implementation of innovative means of transport.

## 3. INNOVATION IN TRANSPORT

Innovation in transport means *improvement of already existing or introduction of new solutions or processes concerning all aspects of changes and contributing to increase of economic, financial, technical and technological efficiency, transport systems environment in order to maximize social effects and management results by public and private sector* [Stawarska E., p. 64].

Innovation in transport may concern many areas - transport technology, planning, organization and management of transport systems, transport financing (new infrastructure, vehicles and other investments, modernization, maintenance of existing resources) [Centrum Analiz Transportowych i Infrastrukturalnych, p. 3]. Innovation in transport refers to the creation or better use of:

- means of transport;
- transport infrastructure;
- the potential of: transport systems, transport and logistics enterprises, producers of transport means, state administration and local governments to plan, organize and manage transport systems.

The literature on the subject distinguishes a number of divisions of transport innovations. One of them is the division into product, process and service innovations. Product innovation in transport is *the introduction to the transport market of a product whose technological or purpose features differ significantly from previously proposed and marketed products or whose operation has been significantly improved, and at the same time it can provide the recipient (consumer) with objectively new or increased benefits*. Process innovation is *the adoption of new or significantly improved methods of operation (processes) in various aspects of transport services, production of means of transport or other transport products, transport management (it may involve changes in technology, organization, methods of work, human resources, equipment)*. Service innovation is *the introduction to the market, transport or logistics service that is new or is perceived by the market as new. This service must offer the consumer a new advantage or value. Such an innovation consists in changing the*

characteristics, quality or effectiveness of the existing service, possibly proposing a new one. [Centrum Analiz Transportowych i Infrastrukturalnych, pp. 4-5

4. MODE OF TRANSPORT OF THE FUTURE – HYPERLOOP

The dynamically developing area of transport innovations opens new possibilities in the scope of modification and introduction of new solutions to the current transport system. The future of transport (in particular means of transport) depends to a large extent on technological development. Currently, new and improved solutions are being developed that allow to improve the previously known means of transport, and innovative, previously unprecedented solutions are being developed.

Hyperloop is a concept of a super-fast mode of transport, referred to as "*the fifth mode of transport*", which was presented by Elon Musk, founder of PayPal, SpaceX and Tesla Motors.

Hyperloop is an innovative mode of transport (connection of train and plane) whose task is to move people or loads at very high speed, based on the concept of sustainable transport [Hyper Poland, online]. The structure resembles a capsule, which is to move in closed, suspended in the air or placed underground pipes (filled with low pressure) [Musk E., online]. Driving capsules is to be carried out thanks to magnetic linear accelerators placed on the route. The capsule itself includes: engine, compressor, rotors and batteries. The energy needed to power the system comes from solar batteries placed on the pipe [May M., online]. The technologies used will allow for the maximum acceleration of the Hyperloop to the speed of approximate velocity of sound, or approximately 1220 km / h (average velocity on "difficult" sections and in urbanized areas - around 480 km / h). Capsules will be able to start on average at intervals of 2 minutes (in peak conditions, at most every 30 seconds) [Werner M., Eissing, K., Langton S., pp. 4-5].

In May 2017, Hyperloop One conducted a successful test of Hyperloop drive in the tube and in the conditions in which passengers will travel in the future (among others: low pressure, the use of magnetic levitation) [Transport publiczny, online].

The advantages of the Hyperloop system include [Ledzian P., p. 81]:

- innovation,
- unrivalled travel time,
- self-sufficiency in the field of energy - the use of renewable energy sources,
- safety and collision-free,
- less harmful than other transport modes, the impact on the environment,
- ensuring a high level of mobility and accessibility,
- less occupied space, e.g. compared to railways.

Hyperloop's criticism refers, among other things, to its construction costs. According to Elon Musk, the construction of the section between Los Angeles and San Francisco is expected to absorb about \$ 6 billion, but the costly development research process has not been included in the cost estimate. The problem may also be the construction of infrastructure for Hyperloop (especially in cities, where the existing buildings are a barrier). Another disadvantage of Hyperloop technology is the design - it forces a half-sitting position, which results in the lack of the possibility of getting up and moving around the capsule (no possibility of getting help in case of danger or illness) [Wolverton T., online].

5. PROPOSAL FOR IMPLEMENTATION OF THE INNOVATIVE MODE OF TRANSPORT - HYPERLOOP – EUROPE

For the purpose of this article, selected (random) European cities were combined and estimated in an optimistic and pessimistic variant travel time between them using Hyperloop.

Table 1. European cities in terms of area and number of inhabitants.

No.	1	2	3	4	5	6	7	8	9	10
City	Barcelona	Berlin	London	Madrid	Paris	Prague	Rome	Stockholm	Vienna	Warsaw
Area [km <sup>2</sup> ]	101.4	891.85	1,572	607	105.4	496	1,287	414.01	414.87	517.24
Population	1,608,746	3,520,031	8,730,803	3,165,541	2,220,445	1,267,449	2,869,461	1,689,952	176,646	1,735,442

Source: own study based on: ec.europa.eu/Eurostat (access: 14.06.2018).

10 European cities were selected (randomly): Barcelona, Berlin, London, Madrid, Paris, Prague, Rome, Stockholm, Vienna and Warsaw. Table 1 presents 10 European cities in terms of area and population.

Table 2 shows the distance between selected cities in Europe. Taking into account the specificity of technology requirements - *the full use of Hyperloop technology is possible when the infrastructure runs with the least number of distortions in the form of turns* [Ledzian P., p. 76],

the distance (km) between the cities has been calculated in a straight line. The calculations also do not take into account the legal status of the site, the location of water reservoirs, terrain or architectural barriers.

Tables 3 and 4 estimate the travel time between the above-mentioned cities in two variants - optimistic and pessimistic. The optimistic variant assumes that Hyperloop moves with the maximum assumed speed - 1220 km / h. In the pessimistic variant Hyperloop moves 480 km / h - taking into account "difficult" sections and built-up areas.

Table 2. Distances in a straight line between selected cities in Europe.

Distance (km)	Barcelona	Berlin	London	Madrid	Paris	Prague	Rome	Stockholm	Vienna	Warsaw
Barcelona	-	1,498	1,138	505	832	1,354	857	2,277	1,347	1,862
Berlin	1,498	-	930	1,868	877	280	1,182	810	524	516
London	1,138	930	-	1,263	341	1,035	1,434	1,431	1,233	1,446
Madrid	505	1,868	1,263	-	1,053	1,774	1,361	2,592	1,807	2,288
Paris	832	877	341	1,053	-	885	1,106	1,542	1,034	1,366
Prague	1,354	280	1,035	1,774	885	-	922	1,053	251	515
Rome	857	1,182	1,434	1,361	1,106	922	-	1,975	763	1,316
Stockholm	2,277	810	1,431	2,592	1,542	1,053	1,975	-	1,242	808
Vienna	1,347	524	1,233	1,807	1,034	251	763	1,242	-	557
Warsaw	1,862	516	1,446	2,288	1,366	515	1,331	808	557	-

Source: own study based on: <http://www.mapcrow.info> (access: 14.06.2018).

Table 3. Optimistic variant - travel time Hyperloop for selected cities in Europe.

Time (t)	Barcelona	Berlin	London	Madrid	Paris	Prague	Rome	Stockholm	Vienna	Warsaw
Barcelona	-	74	56	25	41	67	42	112	66	92
Berlin	74	-	46	92	43	14	58	40	26	25
London	56	46	-	62	17	51	71	70	61	71
Madrid	25	92	62	-	52	87	67	127	89	113
Paris	41	43	17	52	-	44	54	76	51	67
Prague	67	14	51	87	44	-	45	52	12	25
Rome	42	58	71	67	54	45	-	97	38	65
Stockholm	112	40	70	127	76	52	97	-	61	40
Vienna	66	26	61	89	51	12	38	61	-	27
Warsaw	92	25	71	113	67	25	65	40	27	-

Source: own study.

Table 4. Pessimistic variant - travel time Hyperloop for selected cities in Europe.

Time (t)	Barcelona	Berlin	London	Madrid	Paris	Prague	Rome	Stockholm	Vienna	Warsaw
Barcelona	-	187	142	63	104	169	107	285	168	233
Berlin	187	-	116	234	110	35	148	101	66	65
London	142	116	-	158	43	129	179	179	154	181
Madrid	63	234	158	-	132	222	170	324	226	286
Paris	104	110	43	132	-	111	138	193	129	171
Prague	169	35	129	222	111	-	115	132	31	64
Rome	107	148	179	170	138	115	-	247	95	165
Stockholm	285	101	179	324	193	132	247	-	155	101
Vienna	168	66	154	226	129	31	95	155	-	70
Warsaw	233	65	181	286	171	64	166	101	70	-

Source: own study.

Taking into account the distances of the cities, the furthest (in a straight line) from each other are Stockholm and Madrid - 2592 km, while the closest to each other lie Vienna and Prague - 251 km.

In the optimistic variant, the route - Stockholm - Madrid, traveling Hyperloop would be defeated in 2 hours 7 minutes, while in the pessimistic scenario the travel time would be extended to 3 hours 24 minutes.

In the optimistic variant, the route - Vienna - Prague, traveling Hyperloop would be defeated in 12 minutes, while in the pessimistic variant the travel time would be 31 minutes.

In comparison, the journey by car from [Trasa.info, online]:

- Stockholm - Madrid takes 9 hours 6 minutes on average (the shortest travel time);
- Vienna - Prague takes 3 hours 24 minutes on average (the shortest travel time).

## 6. CONCLUSION

Hyperloop is an innovative mode of passenger and freight transport. It will enable moving at very high speed, based on the concept of sustainable transport - the inclusion of transport in the long-term economic and ecological stability (is associated with the promotion of effective transport, which meets the expectations of consumers, while minimizing the harmful impact of transport on society and the environment).

Hyperloop is a technology designed to travel long distances. Taking into account the existing means of transport, Hyperloop significantly stands out in terms of travel time. Based on the results of the proposed implementation, moving the mode of transport - Hyperloop in relation to traveling by car is much more beneficial - in the optimistic variant, the route - Stockholm - Madrid (2,592 km), traveling Hyperloop would be defeated in 2 hours 7 minutes, while by car this distance takes on average 9 hours 6 minutes (the shortest travel time). In combination with other advantages resulting from the implementation of this technology (innovation, safety and collision-free, environmentally friendly, self-sufficient in energy, ensuring a high level of mobility), Hyperloop can prove to be the most effective in terms of both economic and environmental mode of transport and response to contemporary problems related to transport.

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