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Marketing Research Project to Study the Attitudes and Preferences of Travelers Towards an Innovative Mode of Transport in Poland*

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Abstract

The article presents the assumptions and process of marketing research conducted by the Hyperloop Consortium as part of a project to assess the social, legal, economic and technological possibilities and limitations of implementing vacuum rail technology in Poland. Vacuum rail is perceived as a very innovative, future-oriented, energy- and time-saving transport solution, which is being researched in many countries. The growing number of scientific publications on Hyperloop demonstrates the importance of research on the concept, although most of them focus on technical and design aspects. The research described in this article is a pioneering study that combined an evaluation of social acceptance of the concept, passenger attitudes, concerns and perceived risks, and their experience of simulated Hyperloop ride. The quantitative and qualitative research was followed by experiments using a virtual reality-based transport module simulator. The experimental procedure included: video presentation, a few-minute VR ride accompanied by psycho-physiological measurements and a questionnaire survey. The next phase of the research procedure (with corresponding stages) included tests using a mechanical simulator of the vacuum rail passenger module. The results of the survey verified the initial assumptions of the project and provided important information on the conditions of vacuum rail travel, the equipment of the passenger modules, the accepted price level and the solutions expected or suggested by the passengers. The positive reception of vacuum rail technology by potential Hyperloop passengers indicates a very positive attitude towards this innovative mode of transport and optimistic assumptions about the possibility of implementing this solution in Poland.

Keywords: marketing research, passenger transportation, Hyperloop, Poland

Introduction

The vacuum railroad concept emerged as a response to the existing transportation systems (road, rail, water, and air transport), and it is assumed that the Hyperloop technology (Almujibah, Kaduk & Preston 2020, Stryhunivska, Gdowska & Rumin 2020) gives an advantage over the mentioned solutions - which are still an object of dissatisfaction. Vacuum railroad is the idea of an innovative mean of transport that will be fast like air transport, but cheap like the road one (Ross 2016, Mielczarek & Foljanty 2019). Traffic is to take place inside tunnels partially filled with vacuum - the capsules moving through them will transport people or goods (Niu, Sui, Yu, Cao & Yuan 2020).

The research project carried out within the framework of the program "Social and economic development of Poland in the conditions of globalizing markets GOSPOSTRATEG" entitled *Potential for development and implementation of vacuum rail technology in Poland in the social, technical, economic and legal context* was carried out by a consortium consisting of: Ministry of Economic Development, Labor and Technology, Kozminski University, AGH University of Science and Technology, Warsaw University of Technology (National Center of Research and Development, agreement no. Gospostrateg1/387144/27/NCBR/2019).

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The research work carried out provided answers as to whether and why it is worth investing in the development of vacuum rail technology (Hyperloop) in Poland, and how this technology should be supported. Numerous global studies indicate that vacuum rail could become one of the new means of transportation within the next decade (Abdelrahman, Sayeed & Youssef 2018, Blazejczyk & Różycka 2018, Dudnikov 2018, Santangelo 2018, Zhou 2018, Kowal, Ranosz, Kłodawski, Jachimowski & Piechna 2022). This technology could be an interesting alternative to other means of transport especially for connections over distances between about 100 and about 500 km, which makes it particularly interesting from the point of view of Poland and other countries in the region. Transportation systems are still developing today and will always develop - economic changes and technological advances mean that there is still room for improvement - such as raising the standard of travel or minimizing its economic, human, or time-related costs.

The concept of a vacuum railroad model for research purposes

The basic problem in the research project was the development of a concept of vacuum railroad functionalities and the construction of it's a vacuum train models facing the absence of any benchmarks. The main advantage of vacuum railroad is the expected short time between entering the station starting the journey and leaving the destination station. Thus, in addition to the expected high speed of travel, it was important to reduce the times of all intermediate stages, such as passing through security gates, taking seats in the vehicle, leaving the vehicle and the station. Shortened travel times come with some unavoidable comfort constraints for passengers, such as access to toilets during travel, lack of in-vehicle mobility, etc. (Niu et al., 2020, Stryhunivska, et al., 2020, Piechna 2021).

As an optimal solution, the principle of building vehicles with the minimum allowable lateral dimensions, resulting from the dimensions of the people traveling in a seated position, was adopted. After considering a variety of requirements for vacuum rail vehicles operating in long tunnels in which low pressure is maintained, considering possible expectations of passengers, the limitations of current technology and safety considerations, it was decided on a modular form of a vehicle design (Piechna 2022).

It was assumed that the vehicle must fulfill three basic functions: mobility, safety, and comfort. The mobility function is understood as the ability to accelerate quickly and maintain a high travel speed over a long section of the tunnel. The function of ensuring safety, is to isolate the area of the vehicle occupied by passengers from the unfavorable environment in the tunnel and to ensure proper climatic conditions there (supply of oxygen, removal of carbon dioxide and heat). The comfort function is to ensure that the vehicle seating area is occupied and vacated quickly at the start and end stations and has an attractive interior with virtual windows. It was assumed that each of these functions would be provided by a structurally separate module (Hyperloop Consortium 2020).

With these assumptions, the technical documentation for the mechanical simulator was developed and the simulator in question was built. The virtual simulator (VR) required a broader scope of work, including the development of the structure and appearance of the station with platforms, adapted to the vehicles developed according to the assumptions presented.

Marketing research design for assessing passenger attitudes

The research process consisted of 3 phases serving different purposes and using diverse research methods.

1. Exploratory research on public perceptions and identification of travel needs
2. Social research involving the use of VR technology
3. Social research using a mechanical vacuum railroad simulator.

Of course, social research was accompanied by parallel economic analysis, risk analysis, computer simulations of logistic and technological solutions, analysis of legal constraints, etc. (Stryhunivska et al. 2020, Kowal et al. 2022). In this paper the focus is only on presenting the assumptions of marketing research.

The purpose of the research conducted as part of the project "*Potential for the development and implementation of vacuum rail technology in Poland in the social, technical, economic and legal context"* was to determine the level of social acceptance of travel conditions in vacuum railroad vehicles (Hyperloop Consortium 2020).

At the same time, the results of the research were used to develop tools for creating positive attitudes in society towards low-pressure rail, which was identified at the design and research stage as a very attractive method of movement and transportation (Żurkowski 2017). Therefore end, it was necessary to find out the main factors influencing the level of satisfaction with the ride and concerns about the use of vacuum rail technology, which will

facilitate the shaping of information messages on the subject so that attitudes toward Hyperloop are as good as possible (Gregor & Kalicinska-Kula 2014).

The implementation of the research required cooperation and coordination of work between the AGH-UST in Krakow as the entity developing the research work plan, preparing the measurement tools and carrying out the social survey, and a team from the Department of Mechanical Engineering of Power and Aeronautics at the Warsaw University of Technology, responsible for the construction and preparation for testing of the virtual reality (VR) simulator and the physical demonstrator of the passenger module, used as a mechanical simulator of the vacuum railroad.

During the preparatory stage, the AGH team, on a consultative basis, participated in the project to develop the concept of the VR simulator and mechanical simulator, and the related preparation of materials presenting the Hyperloop idea and solutions. With the source materials obtained from the Kozminski University team that carried out the social research in Phase 1, a survey measurement questionnaire was developed. This was followed by the evaluation and selection of measurement tools (EEG wristbands, HRV watches) necessary to make physiological measurements regarding the evaluation of travelers' comfort and preferences (Agarwal & Dutta 2015, Gregor & Wdowiak 2016, Gordon, Ciorciari & van Laer 2018).

The subject of the analysis, according to the research assumptions described in the project proposal, was the opinions of respondents collected through surveys and biomedical signals recorded during the respondents' rides with the two mentioned simulators. The juxtaposition of these two types of information (declarative opinions and physiological measurements) made it possible to verify the veracity of the opinions expressed by the respondents (Disterheft & Wozniak 2017). The adopted research design gave the opportunity to extract the impressions and opinions of respondents relating to the subsequent stages of the journey and the components of the passenger module.

The procedure of the study included dividing the study participants into the following groups:

1. survey group - quantitative survey (n=1500), by CAWI method,
2. focus groups - qualitative study (n=28); three Focus Group Interviews,
3. VR group - C (control, n=37): social study using virtual reality simulator; accompanying simulator ride, psychophysiological measurements (EEG MUSE wristband, HRV watch),
4. VR group (n=39): social survey using virtual reality simulator; psychophysiological measurements accompanying the simulator ride (EEG MUSE armband, HRV watch); modifications to rearrange questions in the questionnaire and procedure for guiding the respondent through surveys and research in the VR simulator),
5. group "mechanical simulator - C" (control, n=35): social study using a vacuum rail mechanical simulator; accompanying the simulator ride, psychophysiological measurements (HRV watch) and timing of activities performed,
6. group "mechanical simulator" (n=67): a social survey using a vacuum rail mechanical simulator accompanying the simulator ride with psychophysiological measurements (HRV watch) and measurement of the time of activities performed; modifications involving changes in the layout and scope of questions in the questionnaire; modifications to the simulator ride related to the presentation of images on virtual windows and the central screen in the mechanical simulator capsule.

Stage 1 – understanding travel preferences

The purpose of the exploratory research was to describe and understand the baseline: public perceptions of currently operating and possible future modes of transportation and travel preferences in the broadest sense. Specific objectives included a comparative analysis of satisfaction with currently available modes of transportation by category of travel, considering key criteria for selecting the modes in question for a particular destination, and public perceptions, expectations, and concerns about emerging transportation systems, including specifically the vacuum rail system (Hyperloop Consortium 2020).

Quantitative and qualitative research methods were used to build an in-depth picture of mobility behaviors, preferences, and expectations regarding future technologies.
The quantitative survey was conducted using the CAWI method, on an online panel of more than 100,000 participants, with a sample size of 1,500 respondents, in June 2019.

The quantitative survey enabled to understand how often Poles travel in a certain way and what factors determine the choice of a particular mode of transportation. It also checked whether respondents were aware of the existence of such technology as Hyperloop, and after an initial presentation during an online interview, respondents were asked about attitudes and preferences regarding vacuum railroad.

The qualitative survey consisted of three focus group interviews – participants in two interviews were residents of the Warsaw agglomeration (capital city of Poland), and one - of the Łódź agglomeration. The qualitative study served to deepen the understanding of causation by analyzing responses to the question of why participants make certain choices now, and why they have certain attitudes toward future technologies. The qualitative study also provided a better understanding of the emotions that are associated with a particular preference, which are of great importance when responding to an innovative mode of transportation (Hyperloop Consortium 2020).

Stage 2 – experiments with the use of VR technology

Analyzing scientific and media publications (Ross 2016, Abdelrahman et al. 2018, Zhou 2018, Musk 2019, Almujibah et al. 2020) on vacuum rail technology and the results of the research from Stage 1, it can be presumed that interest in this technology will be very high, but effective demand for a vacuum rail ride will not be evenly distributed in society. It was also assumed that, at least in the initial phase of the introduction of the innovative means of transportation, tickets for low-pressure rail travel will be rather expensive. Therefore, a purposive sampling was adopted, targeting potential groups more open to accepting this type of innovation. At the same time, due to the peculiar epidemic situation, the snowball method (Maison 2020) was used to search for further participants in the study.

The selection of the sample was also determined by the nature of the study itself, the subject of which is mainly opinions and feelings, described mainly using nominal or ordinal variables (Kaczmarek, Olejnik, Springer 2013).
For the VR (virtual reality) simulator study, the selection of respondents was handled by employees of the AGH University of Science and Technology, and for the mechanical simulator study, employees of the Warsaw University of Technology were responsible for recruiting respondents.
The first stage of the research process related to the collection of primary data, using the VR simulator was carried out in July/August 2020.

Seventy-six respondents took part in this part of the study. The respondents were divided into two groups: a basic research group (37 people) and a control group (39 people). The full research process, to which the basic research group was subjected, consisted of the following phases:

- Part I of the survey (face-to-face computer-assisted survey) to identify respondents' travel experiences and factors influencing their choice of transportation modes,
- Presentation of Hyperloop technology - a video prepared by the PW team and a description of the research procedure,
- A several-minute virtual ride on a low-vacuum railroad simulator and accompanying physiological measurements (heart rate and EEG signal measurement),
- Part II of the survey - respondents' assessments of low-pressure rail solutions, transit comfort and perceived prospects for Hyperloop use.

The drive-through was conducted individually, which allowed measurement of respondents' heart rate and brain waves (no interference with each other's measurements). During the ride, respondents' heart rates were measured using HRV watches, and averaged brainwaves were recorded using the Muse EEG armband, which made it possible to observe selected physiological changes in respondents during the virtual journey (Nawrocka, Kot & Nawrocki 2012, Janiszewski, Kuo, & Tavassoli 2013, Kenning, 2014, Lin, Cross, Jones & Childers 2018). Measuring transit time allowed detailed recording of changes in the respondents' biological signals and comparing them with the different stages of the virtual journey. The results were recorded on complementary tablets.

The survey questionnaire for the primary research group included questions on the following topic areas:

- individual travel experiences,
- use of special transportation solutions,
- familiarity with the Hyperloop concept,
- evaluation of the vacuum railroad concept,
- travel comfort rating,
- evaluation of a vacuum rail vehicle.

The surveys of the control group were modified so that respondents in this group gave their opinions on the key elements of the technological solution under study based on the description they had read and the video they had watched of the vacuum railroad, prior to the virtual ride. Immediately after the ride, they only described their impressions related to the comfort of the journey itself. The scenario of the study established in this way was to isolate possible differences in the attitudes of the two groups and to determine to what extent the possibility of a virtual travel

experience differentiates the respondents' opinions on Hyperloop technology itself and the validity of its implementation. (Kaczmarczyk 2014, Porowska 2016, Mościchowska & Rogoś-Turek 2020).

This is particularly important, because in various sources of information (research results from Stage 1 & several secondary sources of information (Ross 2016, Polak 2017, Zhou 2018, Musk 2019, Almujibah et al. 2020) one can observe a lot of very positive, even enthusiastic opinions about the studied solution, made by people who have not actually encountered the solution. For obvious reasons, it is important to verify these opinions thanks to the opportunities provided by the virtual reality simulator and the vacuum rail mechanical simulator.

Besides, it should be borne in mind that the visual and usability parameters of vehicles and the entire journey can be modified, even quite significantly, and the journey should incorporate as many user expectations as possible (Prymon-Ryś 2010). The high level of technological sophistication of the solution means that in some cases the ideas of potential users, both in terms of the appearance itself and the way the vehicle is used, may be very different from the designers' concepts. That's why, especially within the framework of research using a mechanical simulator, modifications were made to the driving conditions, related, among other things, to the way virtual windows are used in the vehicle and the various possibilities for displaying changing content in them.

Stage 3 – experiments using a mechanical vacuum railroad simulator

The second phase of the data collection process was carried out by the AGH-UST team at the Warsaw University of Technology in August 2020 and included social research using a mechanical simulator of a vacuum rail transport module. It consisted of the following phases:

- Presentation of a video on Hyperloop technology and explanation of the study,
- experimental ride in passenger module's mechanical simulator in groups of 6 and accompanying measurement of heart rate using HRV watches (measurement of brainwave frequencies using EEG bands was impossible due to interference caused by the participation of several people in the experiment and interactions occurring between travelers (Wang & Minor 2008, Nawrocka et al. 2012)); the ride was monitored and recorded using cameras located inside the module ,
- survey research including evaluation of comfort and transit conditions, as well as evaluation of the functionalities used in the passenger module (electronic survey technique on a web panel).

In the study, a proper research group and a control group were distinguished, which included - 67 and 35 respondents, respectively. The control group gave a general opinion on the technological solution itself, while in the research group the survey was aimed at the evaluation of the capsule and the comfort of the ride, while the conditions and functionalities in the passenger module were modified.

The questions in the research questionnaire covered the following subject areas:

- vehicle capsule assessment,
- experience of traveling on the vacuum railroad simulator,
- assessing the comfort of vacuum rail vehicle,
- evaluation of additional design solutions introduced in the device.

The scenario of the ride in the mechanical simulator included: the measurement of transfer time to the passenger module with the hand luggage provided; loading the luggage and taking a seat in the capsule; the ride in the simulator in a group of 6, during which the travelers were subjected to overloads resulting from the acceleration and braking of the vehicle; and leaving the capsule with the luggage. For this reason, it was possible to measure the times of individual activities, for the team creating a logistics model of the station and platform.
In the mechanical simulator test procedure, test conditions were distinguished due to image modifications in the virtual windows i.e.: VR simulator video without central screen, central screen static information about the route of travel, presentation of a video of a high-speed railroad in China, an electronic clock.
The final stage of the research process was to analyze the collected research results, develop conclusions and prepare a research report.

Limitations of the study

Due to the specific period in which the research was conducted (Covid-19 epidemic restrictions) it was necessary to consider the need to implement a strict sanitary regime throughout the research process. The regulations in force enforced frequent disinfection of equipment, ventilation of rooms and implementation of other additional measures to ensure epidemic safety, which certainly prolonged and heavily formalized the research process itself. It can be presumed that these additional activities may have affected the course of the entire research process and even its results, since the subject of the research was such a delicate matter as the emotions of the respondents and their

attitudes towards the technological solution being evaluated. However, due to the projected long-term nature of the epidemic, it was not possible (or advisable) to carry out this research at another time.

Conclusions

The purpose of the marketing research was to determine the level of public acceptance of travel conditions in vacuum rail vehicles. The research process started with qualitative and quantitative research identifying attitudes and preferences of Poles towards travel and innovative means of transport. Further experimental studies included: a questionnaire survey, a video presentation of low-vacuum rail technology, a several-minute virtual ride on a low-vacuum rail simulator and accompanying physiological measurements (heart rate and EEG signal measurement). The survey questionnaire included questions on the following topic areas: respondents' experience of using special transportation solutions and individual travel experiences, familiarity with the Hyperloop concept, evaluation of the low-pressure rail ride and assessment of travel comfort, evaluation of price conditions associated with vacuum rail travel, and evaluation of Hyperloop as an innovative mean of transportation.

In the next stage of research with the mechanical simulator, the technological solution itself, the capsule and the comfort of the ride were evaluated, while the conditions and functionalities in the passenger module were modified. The questions in the research questionnaire covered the following topic areas: evaluation of the passenger capsule, feelings about traveling on the vacuum rail simulator, evaluation of travel comfort, evaluation of vacuum rail as an innovative transportation solution, evaluation of additional design solutions possible in the passenger module.

The results of the survey made it possible to verify the initial assumptions of the vacuum rail project and to obtain important information on the conditions of vacuum rail travel, the equipment of the passenger modules, the accepted price level and the solutions expected or proposed by passengers. The statements of the survey participants, expressed in the form of answers to open-ended questions in the questionnaires, were collected and analyzed. These responses demonstrate the high level of emotional involvement of the respondents. The survey of potential Hyperloop passengers reveals a very positive perception of this innovative means of transport and optimistic assumptions about the possibility of implementing this solution in Poland.

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